GUIDE TO INFORMATION MANAGEMENT

In the context of the Convention on Biological Diversity

UNEP

WORLD CONSERVATION MONITORING CENTRE

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WORLD CONSERVATION MONITORING CENTRE

The World Conservation Monitoring Centre, based in Cambridge, United Kingdom, is a joint venture between three partners in the World Conservation Strategy and its successor Caring for the Earth: IUCN - World Conservation Union, UNEP - the United Nations Environment Programme, and WWF - the World Wide Fund for Nature. The Centre provides information services on the conservation and sustainable use of species and ecosystems and supports others in the development of their own information systems.

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BACKGROUND

The Convention on Biological Diversity was signed at the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992 by 154 nations and subsequently came into force in November 1993. Article 7 of the Convention is concerned with identification and monitoring activities to support Articles 8 to 10 (*in-situ* conservation, *ex-situ* conservation and sustainable use of components of biological diversity). Contracting parties are required to identify components of biological diversity important for conservation and sustainable use (Article 7a); to identify activities likely to have adverse impacts (Article 7c); and to monitor the status of both components and threats (Articles 7b and 7c). Specifically, Article 7d identifies the requirement to: 'Maintain and organize, by any mechanism, data derived from identification and monitoring activities'.

In response to this requirement a project was initiated by the United Nations Environment Programme and the World Conservation Monitoring Centre to facilitate the building of national capacity for biodiversity data management and exchange as required by the Convention. One of the outputs of the GEF-funded Biodiversity Data Management (BDM) Project is a set of supporting materials designed to raise the profile of biodiversity information in decision-making processes and help countries produce the necessary information for biodiversity strategies and action plans. The materials, which were prepared by WCMC, comprise:

- **Guide to Information Management (this document)**

  Recognizing that biodiversity information depends on access to data from many and varied stakeholders, this document examines the organizational issues associated with establishing effective cooperation. A step-by-step information cycle is proposed, comprising agreement on priority issues, determination of information needs, design of information products, agreement of stakeholder roles, and enablement of stakeholders to ensure information is produced cost-effectively. A participatory approach is emphasized as a means to ensure transparency in information usage.

- **Guide to National Institutional Survey**

  This document examines the role of capacity-building in enabling stakeholders to produce biodiversity information. Techniques for analysing the capabilities and needs of stakeholders are examined, with the aim of seeking efficiencies and determining priority areas for investment in human and technological resources.

- **Electronic Resource Inventory**

  This product, which is provided as a readily searchable electronic publication, provides reference materials on software, hardware, methodologies, standards, common practices, data sources and key organizations relating to biodiversity data management. Its major objective is to document the growing array of standards in biodiversity data and, where these are yet to emerge, to provide case studies or pointers to further information sources such as lead institutions, bibliographic references, and Internet addresses.

Ten countries were selected to implement the BDM Project: Bahamas, Chile, China, Costa Rica, Egypt, Ghana, Kenya, Papua New Guinea, Poland and Thailand. Naturally, each country has differing needs and expectations of the Project. This document helps organizations and individuals in the ten countries implement their own information management priorities by raising awareness of key issues. The main audience, therefore, will be senior managers in government, NGOs and local administrations.

EXECUTIVE SUMMARY

Many nations have confirmed their commitment to the principles of Agenda 21 by becoming parties to the Convention on Biological Diversity and other treaties related to biodiversity conservation, such as CITES, the Convention on Migratory Species (CMS), the Ramsar Convention, and the World Heritage Convention. Treaties directed at stabilizing the global environment have also been signed, such as the United Nations Framework Convention on Climate Change and the Montreal Protocol. Nations now recognise their wider regional and global responsibilities, as well as the need to manage their own environment sustainably. Biological diversity, in particular, has become a concern of central significance as a measure of the sustainability of development activities.

In addition to the reporting requirements of global and regional treaties, nations now realize that the key to strategy development and wise decision-making on the sustainable use of biological resources and the equitable sharing of benefits, depends on having systematically organized information (such as inventories of biological resources, indicators of sustainable use, indigenous knowledge). The information which nations must organize and manage to meet their own needs, as well as respond to specific and implied requirements of these various treaties, is complex and transcends conventional sectoral divisions.

The development of environmental information is taxing to all nations, but particularly strains the capacity of developing countries. It is important, therefore, that national information management infrastructure is developed as efficiently as possible, to serve both tactical and strategic needs as well as the reporting obligations of international treaties.

At all levels there is a growing demand to combine and integrate biodiversity-related data and to share the benefits of advanced technology deriving from publicly-funded biodiversity initiatives. Nations are seeking better access to technology and data through mechanisms such as the Clearing-House, and are receiving feedback from treaty secretariats on the comparative performance of fellow parties. This will contribute to early warning of regional biodiversity issues and help clarify priorities for policy development.

Although we are increasingly aware of the causes of many of the challenges to biodiversity, and we know how to collect and analyse data about these challenges, we are less expert at using the information generated to influence the way in which appropriate policies and legislation are framed, or the way in which biological resources are managed.

Multi-stakeholder information systems (often termed 'information networks') enable us to address this last challenge. They empower groups of organizations and individuals to influence the status quo within a framework of collective information production. Well-produced information generated by respected, wide-ranging groups has great potential to support decision-making processes. Collaboration also leads to greater efficiency.

Although our understanding of multi-stakeholder information systems is still developing, recent experiences show that the greatest challenges are organizational, not technological. By focusing on the processes involved in creating and using environmental information, as opposed to concentrating largely on hardware and software, efforts such as the BDM Project are facilitating progress in this area.

One of the main characteristics of successful information networks is active participation of stakeholders ('network participants'), with a focus on resolving the complex jurisdictional and organizational issues associated with co-operation. Participation generates trust, encouraging stakeholders to 'buy into' the process of keeping essential data maintained and accessible to others.

Another characteristic is that the networks directly support decision-making. This feature is sometimes overlooked, particularly in cases where too much emphasis is placed on data 'gap filling' exercises which do not necessarily reflect the needs of policy makers or resource managers. Information is an expensive commodity and, in developing information networks, it is useful to bear in mind the following questions: What pressing concerns does the planned information address? To which audiences will it be delivered? How can we be sure that it has succeeded?

Cooperative networks of data providers and users are the main ingredients of successful biodiversity information systems. For data to flow easily from one location to another, network participants must feel comfortable working with each other and exchanging data. The principle of custodianship is very useful in this regard. It provides a framework for selecting which organization is best placed to manage a dataset - a crucial step towards ensuring that data are professionally maintained.

Being complex and multi-disciplinary in nature, biodiversity information often requires inputs from a wide range of stakeholders. Potential contributions include data, expertise, financial inputs and physical facilities. In order to co-operate in a coherent, cost-effective manner, it is clear that a guiding framework is needed to focus stakeholder contributions on common goals.

Recognizing that each country will respond uniquely to the challenge of producing biodiversity information, this document presents a flexible, process-oriented approach. Information objectives are broken down into a series of small, achievable steps which progressively empower stakeholders. This step-by-step, participatory approach to information management helps to reduce the costs of information usage, guides managers towards improved policy and management effectiveness, and enhances transparency and accountability. It is centred on five specific processes which, collectively, are referred to as the **information cycle**:

- **Agree the priority issues demanding information**

  Recognizing that resources for information management are limited, this process aims to secure agreement on those issues which most urgently require information in the interests of conservation and sustainable use of biological resources. Large and complex issues, such as 'poverty', 'population growth' or 'deforestation' should be avoided. While undeniably important, they are just too broad to be addressed effectively. More focused issues such as 'drainage of wetland X for agriculture' or 'effect of pollution of river Y on species Z' are more tractable. A high degree of consultation is required during the agreement process, since stakeholders may have widely differing views on priorities. Reconciling different viewpoints by negotiating a consensus on priority issues can help build ties between stakeholders and facilitate cooperation. Where a body exists to coordinate the management of biodiversity information (e.g. a Steering Committee), agreement can be greatly accelerated. For instance, a draft list of priority issues could be prepared and distributed to stakeholders for comment. Alternatively, a workshop or other discussion forum could be held specifically to reach consensus.

- **Determine the information needs of decision-making groups**

  The key to effective use of biodiversity information is to focus on essential information only. In situations where financial resources are scarce this is, inevitably, the information required to set and achieve immediate policy and management goals. However, solutions to biodiversity issues are notoriously complex and it is not always easy to determine what information is essential. One approach is to ask decision makers to articulate their needs directly, but this may not succeed if they have only a hazy idea of their requirements. The price for not pursuing this challenge is heavy: without the 'right' information, incorrect decisions can be made and scarce resources used unwisely. A thorough assessment of information needs is a critical initial step therefore.

- **Design strategic information products**

  Information products provide support to decision makers by addressing the constraints they face on using information. For example, decision makers may be too busy to process large amounts of data or apply themselves to difficult interpretation tasks. By emphasizing presentation issues such as clarity, timing and method of delivery, they make information both useful and usable by its intended audience. Information products bridge the gap between science and policy, since they are designed to transfer scientific ideas into policy-making.

- **Agree stakeholder roles and responsibilities for information production**

  Recognizing that the development of biodiversity information is a multi-stakeholder, multi-disciplinary activity, an efficient mechanism for coordinating stakeholder contributions is vital. One way of achieving this is to establish a high-level body of stakeholder representatives (e.g. a Steering Committee), charged with forming and managing technical teams to deliver its objectives. This two-tier structure breaks down barriers to cooperation by facilitating communication at both organizational and technical levels.

- **Enable stakeholders to deliver the required information**

  Stakeholders may be unable to fulfil their agreed roles due to constraints in human or technological resources, funding, or coordination with other stakeholders. This is particularly true when stakeholders are collaborating on information production for the first time and joint operational procedures have yet to be established. In such circumstances, data can be mobilized by addressing key concerns such as data access, data standards, data

quality and data flexibility. The judicious application of information technology can also be effective. Attention to these topics helps establish reliable working relationships between stakeholders leading to enhanced productivity and cooperation.

This document focuses on the how to make these processes work in practice, ensuring that efforts invested in the information cycle are cost-effective, timely and sustainable.

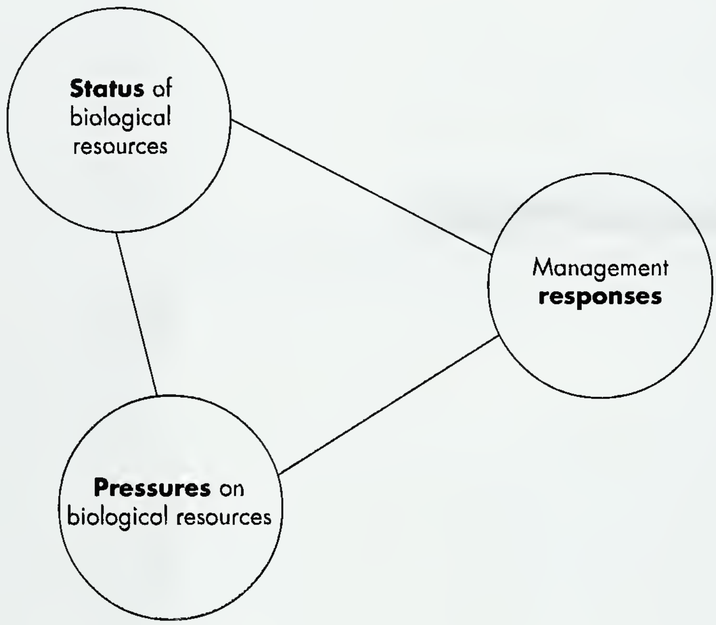
1

DECISION-SUPPORT

INTRODUCTION

The world's biological resources are being degraded due to unsustainable human activities. The changes which are occurring threaten the long-term survival of many lifeforms, including our own. Particularly serious impacts for humankind include the erosion of genetic variability, the decline in health and functioning of ecosystems, the compromise of food and water security, and the emergence of lethal micro-organisms.

Figure 1: Elements of biodiversity information



The major forces behind these impacts are technological innovation, economic development and population growth. These have occurred with increasing speed during the twentieth century, and have done so in an uneven pattern across the globe. This has led to stresses and divisions between nations and smaller groups as they compete for ever-scarcer resources.

One response to the deteriorating situation is the development of national conservation strategies, environmental action plans, sectoral master plans (e.g. national forest action plans) and other policy instruments promoting conservation and the sustainable use of biological resources. In order to be effective, these should utilize sound scientific information on (Bakkes *et. al.* 1994):

- The current status and distribution of biological resources (including trends in space and time);
- The pressures being exerted on biological resources;
- The effectiveness of current policies and management responses.

By illustrating the topics as elements of an integrated whole, Figure 1 emphasizes the need for information on all three to reach sound decisions on biological resource issues. Broadly, the elements correspond to the questions 'what is happening?', 'why is it happening?', and 'what are we doing about it?' respectively (Hammond *et. al.* 1995). From a resource management perspective, information on pressures is often given highest priority, since it is naturally more

cost-effective to address underlying causes than symptoms. Pressures, which are mainly human-induced, are also easier and cheaper to document in general.

Individuals, local communities, industry, sovereign states and international organizations all make decisions which affect the sustainability of biological resources and, consequently, all have a role to play in their conservation. Thus biodiversity is a concern to all sectors and levels of society; decisions made by one group may affect the livelihoods of others. Thus it is important that, where possible, decision-making reflects the needs of all those groups affected by the outcome—i.e. a consensus is achieved.

Groups around the world are recognizing that organized scientifically-based information brings objectivity into this process, throwing light on complex issues and providing a means of comparing potential solutions. They are also recognizing that information is empowering and, as a consequence, are reorienting many of their activities in favour of more effective information management.

Information provides essential support for achieving goals, whether these be for a village, a resource management agency, a nation or a multilateral bank. Environmental information, such as trends in the availability of biological resources, is at least as, if not more important to some groups as economic or political information. Without proper environmental information a village can go hungry, an agency or nation can degrade or destroy valuable biological resources, or an international organization can oversee programmes which have impacts other than those intended.

Many groups already possess information of a cultural, economic or scientific nature which is of great value to the management of biological resources. However, the flow of biodiversity information between different levels and groups in society is often inadequate. The main reason is that many would-be information providers fear, with some justification, that their information may be used incorrectly or against them if released. In this respect there is no difference between owners of indigenous knowledge (IK) and owners of what loosely might be described as global or common[1] knowledge: both may feel uncomfortable about providing information until they are assured of how and why it will be used.

In the broadest sense, information systems are intended to overcome such fears by building trust and confidence between information providers and users. Transparency in information usage, the breaking down of barriers to information flow, and the demonstration of real and tangible benefits in doing so, are the key justifications for building information systems. The aim is to help information providers work together to address national and international conservation priorities, such as policy and legislative development, biological resource management, and implementation of conventions (Stein 1994).

PARTICIPATION

The transition from exploitation of biodiversity to sustainable use will require a major investment in information and monitoring—otherwise we cannot be sure that the solutions found are really sustainable. Those involved must respond by developing information that serves policy and resource management needs, a goal which depends on the participation of a wide variety of stakeholders[2].

Typical stakeholders include politicians, policy makers, resource management agencies, local government administrations, non-governmental organizations, community-based groups, the private sector, industry, scientists, educators, the general public, media, and the international community.

Being multi-level (e.g. international, national, local) and multi-disciplinary in nature, biodiversity issues tend to involve large numbers of stakeholders with widely differing perspectives and needs. Simple answers to complex questions are often inappropriate, and can generate new problems themselves. Indeed, biodiversity issues are frequently obscured by a 'tyranny of small decisions', without anybody taking responsibility for reconciling different points of view.

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[1]Common, or cosmopolitan knowledge refers to the body of scientific knowledge widespread across the globe, which is derived and accepted by Western scientific thinking (CSD 1996).

[2]In the present context the term 'stakeholder' applies to individuals or groups who have an interest in the well-being or management of a biological resource.

Part of the reason why biodiversity issues are so challenging is that the values attached to biological resources vary tremendously between stakeholders. In some cases values may have evolved over thousands of years of interaction with the environment and be embedded in the spiritual life or culture of a community. In others they may have been acquired recently in response to new economic pressures or opportunities. A paradox exists, since the signs of environmental deterioration are clear to many, yet a consensus has not been reached on how to respond (see Box 1).

Box 1: Uncertainty in biodiversity issues

Countries will find that their efforts to measure the value of biological resources and diversity are hampered by tremendous uncertainty. There is uncertainty regarding biological measures of the qualities, quantities, diversity and interactions of biological resources. There is uncertainty of the various goods and services that flow to us from these resources, or that may flow to us in the future. There is also uncertainty about the values members of our society place upon the flows of these goods and services and the values that future generations may place upon them. There is uncertainty about how human actions may impact biological resources and diversity and their associated goods and services, but we face the very real risk that the impacts of our actions may be irreversible. This is clearly the case for the extinction of a species due to unsustainable use or disruption of habitat.

Source: Technical Annex to the *Guidelines for Country Studies on Biological Diversity* (UNEP 1993).

Ways must be found for stakeholders to develop solutions cooperatively, as opposed to those purely in their own interests. Participation in decision-making is a natural solution since this encourages stakeholders to 'buy in' to outcomes and see them implemented. Since good decision-making depends on the availability of sound scientific information, the need for participation applies equally to the development of information as it does to the decision-making itself. Without participation (and therefore transparency) in information development, stakeholders may lack confidence in the decisions made.

DECISION-SUPPORT

The participatory approach does not guarantee that collectively produced information will have the desired impact on decision-making. Its impact is also determined by the way in which the information is presented and the extent to which it is relevant to immediate decision-making needs. In the case of governments, these may be substantially focused on developing and implementing policy and legislative goals. For example, raw data on the status of endangered species may not be usable by decision makers without extensive interpretation and integration with other sources. In contrast, a package of information describing the status of the species, the chief pressures it faces, and the efficacy—or otherwise—of current policy and legislative tools, is likely to have a far greater impact.

Several models have been proposed for biodiversity planning—i.e. the development of strategies, policies, legislation and action plans for conservation and sustainable use of biological resources (e.g. UNEP 1993, Miller and Lanou 1995). Information management figures prominently in these models, mainly as a means of monitoring policy performance and reporting to international conventions and other audiences. However, its potential to deliver efficiency gains and cost savings is not always explored.

An important justification for increased attention to information management is that biodiversity challenges are usually complex and do not respond well to simple solutions. Many viewpoints and sources of information may have to be integrated to find the most appropriate way forward, a process which depends on effective information management techniques. Solutions also need to be monitored closely during implementation to confirm—or otherwise—their effectiveness, and help to design more cost-effective solutions in future. Review mechanisms of this kind are a standard feature of many conservation interventions but, in many cases, the expertise required to collect, assess and deliver the required information is underestimated.

In fact, it has become clear that the major obstacles to increased use of information in decision-making are organizational, not technological in nature, meaning that investments in information technology alone will not provide a solution. We know the causes of many key environmental challenges and we know how to collect and analyse data about them. We also know how to build information systems to manage the data we collect and, for example, summarize information on the status and distribution of biological resources. Such systems have been implemented in many parts of the world.

But there are few cases in which it can be demonstrated clearly that the information produced by such systems has guided the development of national or local-level policies; and even fewer cases where such systems are so well integrated into decision-making that they are depended upon consistently. One of the reasons why biodiversity information has so far failed to be integrated into mainstream decision-making processes is that it is often developed apart from these processes—rather than emerging from within. For information to be appreciated and used, those who are expected to use it must be aware of how and why it has been produced. Thus information production should be emphasized within the day-to-day management contexts of the organizations and groups involved in the business of conservation and sustainable use of biological resources.

Scientific information is only one factor affecting the way in which decisions on biodiversity are made, and is not always the most significant. Other means include political judgement, legal or financial necessity, personal or group bias, and commercial or international pressures. In most cases, the scientific argument for conservation and sustainable use of biological resources is abundantly clear: what remains is to raise awareness of this understanding over competing interests, reinforcing the need for information to emerge from within the decision-making environment.

POLICY DEVELOPMENT

Figure 2 illustrates a generic management process ('management loop') containing four components: *agree/refine policy; implement policy; monitor performance*; and assess performance. By making extensive use of management information the four processes enable policy objectives[3] to be achieved in a progressive, transparent manner. As policies and actions are refined, it is expected that each sub-process in the loop will be visited many times. Indeed, being both cyclical and adaptive, the loop follows the continuous improvement management paradigm.

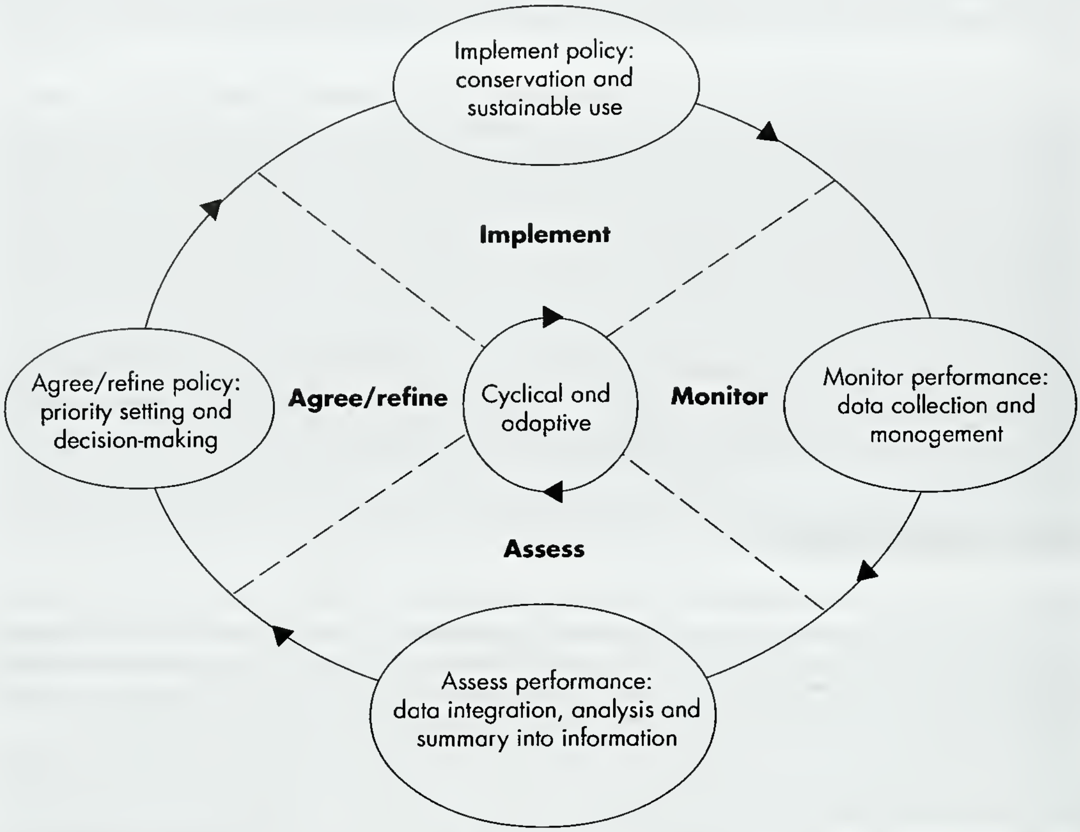
Joining the loop at the implement policy stage, the chief activity is carrying out agreed actions in the policy to achieve conservation and sustainable use. The next stage is to monitor performance, where data on policy effectiveness is obtained either by measuring environmental variables, or compliance with pre-established implementation targets. The assess performance stage involves integrating and analysing the above data into information on policy performance. The loop is 'closed' by the agree/refine policy stage, in which information on policy performance is examined by the appropriate body and recommendations for refinement are agreed.

Figure 2 simplifies what, in reality, is a complex, many-faceted process. For instance, the policy being implemented may address an issue of national importance, such as the loss of crop genetic variability in an important agricultural zone. Conversely, it could address a local concern such as the restoration of a single eroded landscape. In both cases successful implementation depends on maintaining a steady course around the management loop so that the four processes flow into one another. To achieve this it is necessary to concentrate on the core objectives of the policy at all stages and make sure all activities contribute to these in some way.

An open, participatory approach encourages stakeholders from different levels and sectors of society to involve themselves in implementing the management loop. For instance, policy goals may be agreed at participatory forums; community groups or private sector appointees may be asked to monitor policy performance; and the success or failure of biodiversity policies, plus options for future refinement, may be determined as a group.

[3]The phrase 'policy objectives' is intended to cover formal policies of organizations (including governments) and informal, perhaps locally invented policies addressing specific environmental concerns.

Figure 2: Management loop for policy development



When stakeholder perspectives differ greatly, participation is not always easy to manage. In such cases considerable effort may be needed to keep stakeholders focused on the objectives of the management loop, and not let implementation be delayed (see Box 2). Clearly, the management loop is not an easy approach to follow, but does offer a powerful means for developing policies capable of responding to changing environmental conditions in a controlled, transparent fashion.

Box 2: Potential implementation delays

- Policy developed, not implemented. Constraints such as lack of resources, expertise or time can result in good policies never being implemented.
- Policy implemented, performance not monitored. Feedback on policy performance, which may require significant effort to obtain, is commonly overlooked.
- Performance monitored, not assessed. Collection of appropriate data is not enough; effort is needed to assess the implications of policy performance in terms of recommendations on future policy.
- Performance assessed, not used to refine policy. Constraints such as political interference, lack of resources, or lack of will can lead to recommendations not being implemented.

EMPOWERMENT

Depending on the degree of participation in policy development, the groups most likely to require biodiversity information are senior managers in government, the private sector and major NGOs, with community groups, the general public, the media and international bodies also contributing as appropriate. In producing information for such audiences it is important to consider how it will be used. Specifically, good information empowers its audience by providing a range of options; providing a wider context within which to assess impacts; adding to a common basis of agreed facts on which to base debate; and discouraging options with predictably adverse consequences.

Clearly, information will only achieve these empowering goals if it is tailored to the needs of specific audiences (see Chapter 4). This helps to ensure that the information delivered is relevant to decision-making needs; timely (i.e. available when and where it is needed); and easily interpreted without the need for special training or technology. As an example of differing needs, information presented in a scientific journal may serve its intended academic audience well, but its timing may be unsuitable for a policy maker, and its scholarship may deny access to other audiences.

Well designed information can help set environmental agendas. A good example is the release in 1990 of 'greenhouse' gas emission statistics by the World Resources Institute (WRI/UNDP 1990). All major countries were ranked according to their level of emissions, causing immediate attention to and rapid alteration of policy in some cases. This example illustrates 'decision-making by disclosure'—i.e. the delivery of information to policy makers via the public domain, rather than by more traditional channels. This may be appropriate in some situations but can be counter-productive in others. An understanding of the political climate and cultural values of the country is necessary before deciding on the most effective means of using biodiversity information.

2

THE INFORMATION CYCLE

INTRODUCTION

In the previous chapter we focused on the application of information to policy development. A generic approach was taken, capable of evolving solutions in a participative, transparent manner. This chapter (and the remainder of this document) explore the information management processes underpinning policy development. It is proposed that efficient, proven methods are applied in order to mobilize the best available information in support of policy and management goals.

Policy development—or refinement of its policies where these already exist—is one of the key justifications for generating biodiversity information. However, it is also required for other reasons: strategic planning, biological resource management, education, awareness raising and environmental lobbying. Indeed, many biodiversity concerns have yet to be addressed with suitable policies. Thus, in considering which policy and management goals are priority, we should not limit ourselves to those concerns for which some form of policy, however rudimentary, already exists. Loosely, we shall call the wider set of biodiversity concerns 'issues demanding information'. The first step in developing suitable information is to agree what these issues are and, having achieved this, which have the highest priority.

Most issues demanding information result from direct physical, chemical or biological pressures exerted on the environment by human activities. They vary tremendously across the world, depending on the history, culture, trade, politics, climate, and geographic composition of the locations concerned. Box 3 lists just a few typical issues to illustrate their breadth.

Box 3: Typical biodiversity issues demanding information

- Conversion of natural landscapes (e.g. forest to agriculture).
- Decline in commercially valuable species (e.g. timber trees, bushmeat)
- Loss of genetic variability (e.g. wild ancestors of crops).
- Disappearance of indigenous knowledge (e.g. traditional forest-related knowledge).
- Environmental change (e.g. global warming).
- Achievement of sustainable management practices.

Stakeholders may attribute different priorities to such issues according to local perceptions of importance. For instance, although global warming could be one of the major driving forces of environmental change in the next century, it may receive little attention in a low-income community challenged with survival.

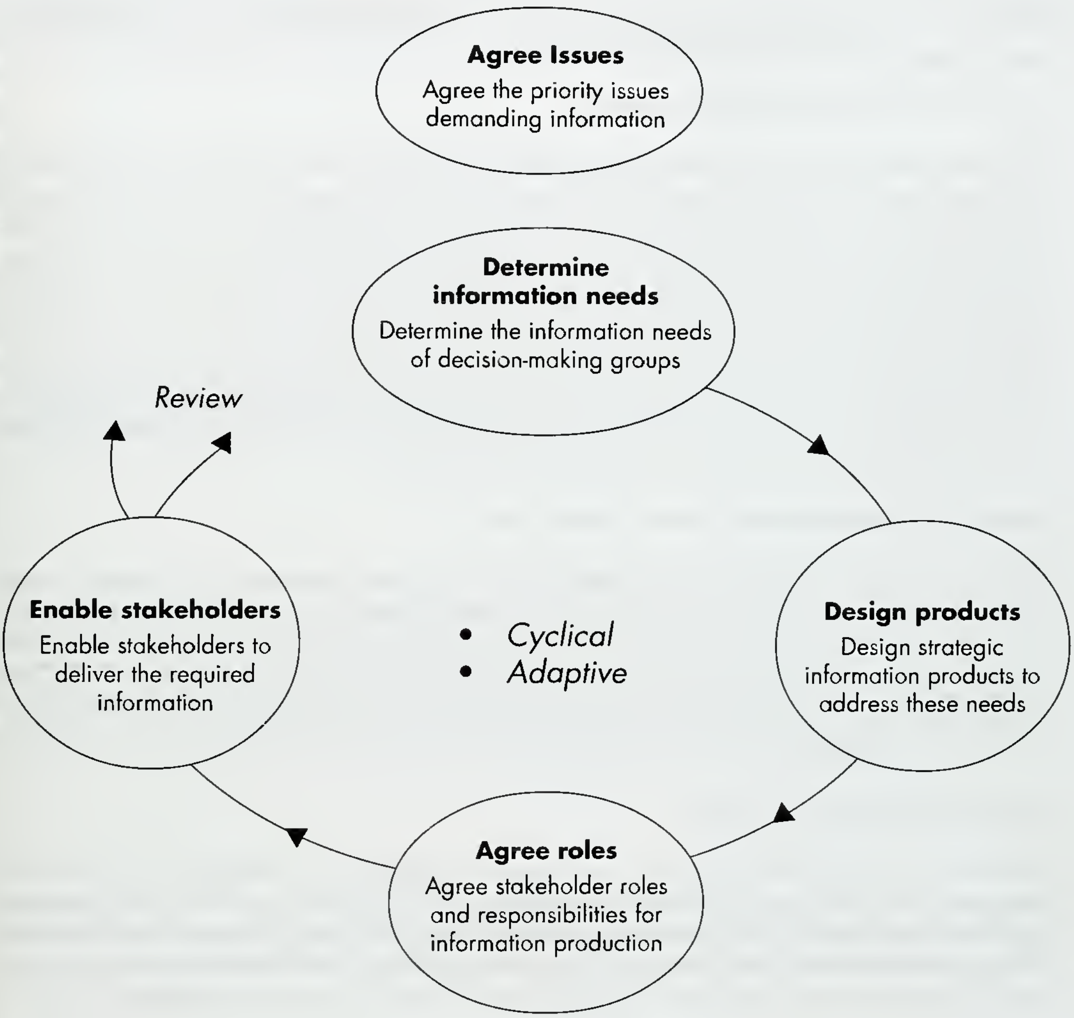
Priorities also change over time: they arise, come to the attention of specific decision-making groups, and then disappear—perhaps to resurface later in a different form. The key challenge in producing biodiversity information is to understand not only what information is needed, but also when, how and to whom it should be delivered to achieve the greatest impact.

THE INFORMATION CYCLE

Being complex and multi-disciplinary in nature, biodiversity information often requires inputs from a wide range of stakeholders. Potential contributions include data, expertise, financial inputs and physical facilities. In order to co-operate in a coherent, cost-effective manner, it is clear that a guiding framework is needed to focus stakeholder contributions on common goals.

Recognizing that each country will respond uniquely to the challenge of producing biodiversity information, a flexible, process-oriented approach is proposed. This breaks down information objectives into a series of small, achievable steps which progressively empower stakeholders. Figure 3 illustrates the approach which, is referred to as the information cycle.

Figure 3: The information cycle



By promoting a step-by-step, participatory approach to information management, the information cycle helps to reduce the costs of information usage, guide managers towards improved policy and management effectiveness, and enhance transparency and accountability.

In many cases, individual processes in the information cycle may have been accomplished already (e.g. agreement of priority issues demanding information), in which case the cycle can be used to suggest next steps or draw attention to missed, or under-emphasized activities. The information cycle is not rigid or prescriptive: different ordering or overlap of the processes is likely due to the completion of certain tasks, the need to revisit processes, or other local priorities or constraints.

COMPONENT PROCESSES

The information cycle consists of five component processes, one of which—*agree issues*—should be undertaken before the others since it establishes overall goals. The remaining four components—*determine information needs, design products, agree roles*, and *enable stakeholders*—cover the activities necessary to produce cost-effective information on the agreed issues. Individual components may be revisited as policies evolve and information needs are refined. An overview of each component follows below:

- Agree the priority issues demanding information

  Recognizing that resources for information management are limited, this process aims to secure agreement on those issues which most urgently require information in the interests of conservation and sustainable use of biological resources. Large and complex issues, such as 'poverty', 'population growth' or 'deforestation' should be avoided. While undeniably important, they are just too broad to be addressed effectively. More focused issues such as 'drainage of wetland X for agriculture' or 'effect of pollution of river Y on species Z' are more tractable. A high degree of consultation is required during the agreement process, since stakeholders may have widely differing views on priorities. Reconciling different viewpoints by negotiating a consensus on priority issues can help build ties between stakeholders and facilitate cooperation. Where a body exists to coordinate the management of biodiversity information (e.g. a steering committee), agreement can be greatly accelerated. For instance, a draft list of priority issues could be prepared and distributed to stakeholders for comment. Alternatively, a workshop or other discussion forum could be held specifically to reach consensus.

- Determine the information needs of decision-making groups

  The key to effective use of biodiversity information is to focus on essential information only. In situations where financial resources are scarce this is, inevitably, the information required to set and achieve immediate policy and management goals. However, solutions to biodiversity issues are notoriously complex and it is not always easy to determine what information is essential. One approach is to ask decision makers to articulate their needs directly, but this may not succeed if they have only a hazy idea of their requirements. The price for not pursuing this challenge is heavy: without the 'right' information, incorrect decisions can be made and scarce resources used unwisely. A thorough assessment of information needs is a critical initial step therefore.

- Design strategic information products

  Information products provide support to decision makers by addressing the constraints they face on using information. For example, decision makers may be too busy to process large amounts of data or apply themselves to difficult interpretation tasks. By emphasizing presentation issues such as clarity, timing and method of delivery, they make information both useful and usable by its intended audience. Information products bridge the gap between science and policy, since they are designed to transfer scientific ideas into policy-making.

- Agree stakeholder roles and responsibilities for information production

  Recognizing that the development of biodiversity information is a multi-stakeholder, multi-disciplinary activity, an efficient mechanism for coordinating stakeholder contributions is vital. One way of achieving this is to establish a high-level body of stakeholder representatives (e.g. a steering committee), charged with forming and managing technical teams to deliver its objectives. This two-tier structure breaks down barriers to cooperation by facilitating communication at both organizational and technical levels.

- Enable stakeholders to deliver the required information

  Stakeholders may be unable to fulfil their agreed roles due to constraints in human or technological resources, funding, or coordination with other stakeholders. This is particularly true when stakeholders are collaborating on information production for the first time and joint operational procedures have yet to be established. In such circumstances, data can be mobilized by addressing key concerns such as data access, data standards, data

quality and data flexibility. The judicious application of information technology can also be effective. Attention to these topics helps establish reliable working relationships between stakeholders leading to enhanced productivity and cooperation.

The remainder of this document focuses on how to make the information cycle work—i.e. ensuring that efforts invested in the component processes of the cycle are cost-effective, timely and sustainable.

INFORMATION NEEDS

3

INTRODUCTION

In the same way that labour, transport and buildings enable managers to run their businesses efficiently, so does information. But like these other production factors, too much information is costly to develop and unnecessary. The key to effective information management is to focus on essential information only. In situations where financial resources are scarce this is, inevitably, the information required to set and achieve urgent policy and management goals. This chapter examines how to determine core information needs.

As was highlighted in the previous chapter, solutions to biodiversity issues can be extremely complex and it is not always easy to determine what information is essential. One approach is to ask decision makers to articulate their needs directly, but this may not succeed where they have only a hazy idea of their requirements. The price for not pursuing this challenge is heavy since without the 'right' information incorrect decisions can be made.

Decision-support is only one reason for producing information, others being research and education. However, assuming that decision-support is the primary motivation there are three main reasons for determining information needs before progressing:

- **Cost-effectiveness**

  Sometimes, in the rush to exploit technology or shed light on natural phenomena, the most basic questions concerning information usage remain unanswered. This can result in time and money being wasted on preparing information or developing information systems which are not used (or usable) by decision makers. In turn this leads to a loss of confidence amongst stakeholders. Successful use of information must be proven early and constantly sustained.

  Various techniques exist to ensure that information does have the desired impact (see Chapter 4). These stem from an understanding that information must be designed with its audience in mind. An understanding of the decision-making process into which information will be delivered (as revealed by the information needs assessment) is a critical first step towards producing cost-effective information. Such an understanding reveals myriad constraints on information usage which might otherwise have gone undetected.

- **Efficiency**

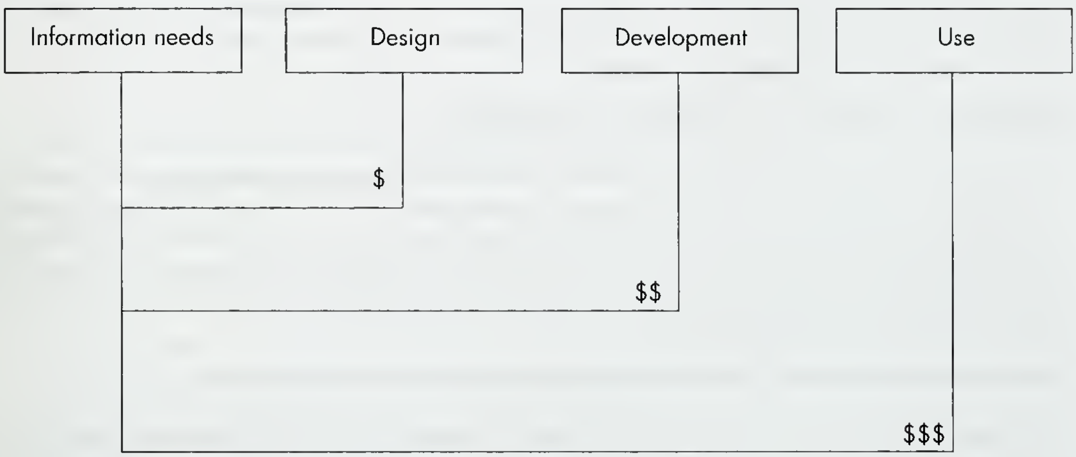
  When building information products, the sooner needs are identified the easier (and therefore cheaper) they are to accommodate (see Figure 4). Changing focus mid-way through the design of an information product can result in delays and additional costs being incurred; changing focus when an information product is actually under development (possibly involving several agencies) costs more; changing focus after delivery of the information to its audience is even more costly and, potentially, damaging to credibility.

  The information needs of different decision-making groups may be surprisingly similar, enabling substantial efficiencies to be made. For example, a senior manager in a ministry of agriculture may require a map showing the distribution of key plant genetic resources in a specific location. This need appears to differ greatly from that of a senior forest officer wishing to know the sustainability of logging operations in the same location. However, much of the baseline data required to build the maps (e.g. administrative boundaries, rivers, vegetation and topography) may be the same. Thus knowledge of information needs from the earliest stages of an information project can save costs by pinpointing areas of overlap and ensuring that common baseline datasets are available.

- **Confidence building**

  Information needs assessment provides an excellent opportunity for constructive dialogue between decision makers and information providers. Involvement of many stakeholders throughout the assessment is useful, since each brings their own perspectives on what information is priority. By involving a wide range of stakeholders at the early stages of an information project, methods of collaboration are promoted and confidence is built in the end results.

Figure 4: Relative cost of change during information production



An indication of the importance of the user (information) needs assessment is provided by Richardson (1994), who claims that this step 'took 80 per cent of the time of the start-up phase' of the Environmental Resources Information Network (ERIN) information system in Australia, and that 'great self-control was needed not to be 'busy' purchasing hardware, software, and data until these matters were settled'.

DETERMINING NEEDS

For any particular issue, information needs can be determined by considering some basic questions about how the information will be used. These include:

- **What specific issue is being addressed?**

  The first process in the information cycle (see Figure 3) seeks agreement on which biodiversity issues demand information most urgently. We noted in Chapter 2 that information production is simplified by defining issues as carefully and specifically as possible, enabling a higher quality, focused information response.

- **Who are the main decision-making/influencing groups?**

  To increase its chance of being absorbed into decision-making, information should be targeted at specific groups (referred to as 'audiences'). Thus for any particular issue, audiences need to be defined on the basis of ability to develop or influence policy at an appropriate scale.

- **How do these groups currently use information?**

  Scientific information may or may not play a large role in deciding how decisions on biodiversity are made. Other influences include political judgement, legal or financial necessity, personal or group bias, and commercial or international pressures. In most cases, the scientific argument for conservation and sustainable use of biological resources is clear; what remains is to penetrate the decision-making process more effectively with information.

- **What constraints do they work under?**

  There is little benefit in delivering biodiversity information to decision makers unless it reaches its audience on time, in an easily interpretable form, and with reputable scientific credentials. For example, if a meeting is scheduled to decide a course of action affecting biodiversity then supporting information must be delivered well before the meeting to have an effect. If it is late, or it is deemed to be too complex or detailed for busy people to comprehend, then it may not even be examined. Such constraints on information usage have to be understood clearly since they are both common and important.

- **Does a policy exist within which decisions are being made?**

  Recognition of many biodiversity issues is so new that few policies or suitable legislation may exist to address them. However, where policies do exist it is important to examine them carefully to see where specific information may be needed. Further, where an obvious policy review mechanism exists it is important to support this with information on policy effectiveness, including recommendations on potential improvements. Where no policy exists, one solution is to identify the decision-making bodies most able to respond to the issue and empower these with relevant background information.

- **What specific information is required to help implement, evaluate or develop policy?**

  This question goes to the core of the information production process. Once areas of management need, policy weakness or policy absence have been detected, it remains to supply specific information to rectify this. The content, format (e.g. length) and medium through which the information is delivered will all contribute to the acceptance and, ultimately, use of the information concerned.

- **How, when and to whom should this information be delivered?**

  Although crucial, this final question is frequently overlooked. The source from which information is delivered can have a major impact on how it is received. Campaigning organizations prone to releasing very negative information about governmental performance may be quietly ignored in governmental circles; but when a governmental committee reviewing the same issue arrives at similar conclusions, the government may change its policy rapidly. As stressed above, the timing of information delivery is also important; so too is the selection of the individual or group to whom the information is sent.

These questions aim to uncover which information is needed to promote effective decisions. The results of such an assessment should be documented and distributed to stakeholders for feedback. Once an agreed position on information needs has been reached, the products and services required to meet them can be designed.

TOOLS AND METHODS

There are many tools and methods for determining information needs. Any particular study may require only a subset of these, the most appropriate methods depending on its depth, the nature of the issue being addressed, the target audience for the information, and the previous experience of the study team. In large projects, formal methods such as data modelling (which results in Entity-Relationship diagrams), process modelling and prototyping are used to structure the assessment results. An example of a formal specification (for BirdLife International) can be found in Van Dijkhuizen (1994), and a less formal example (for the UNEP Office of Harmonization of Environmental Information) in Crain (1992).

- Questionnaires

  Questionnaires are a highly structured method of data collection in which respondents are requested to fill in the blanks on a form. This can be a valuable data collection tool in itself, or as a guide to facilitate data gathering, e.g. in interviews. A properly designed questionnaire promotes the systematic collection, cataloguing and evaluation of data. This eases the summarization of general basic facts and trends. Data collection by this method is inexpensive and efficient.

Questionnaires are best for collecting specific information or opinions on narrow options. The principal value is as a preliminary screening method to help determine which institutions or functions should be studied in more depth. As well, questionnaires can be helpful as a checklist or aide-memoire for conducting structured interviews.

Questionnaires have limitations for open-ended or general assessment of information needs and past experience has shown very low response rates are obtained from 'blind' distribution—that is, mailings without advance warning or explanatory material. Response rates can be improved by including a supporting brochure providing a summary explanation of the purpose of the study and questionnaire, together with a sample questionnaire completed as an illustration. Another technique is to have the questionnaire filled out to the maximum extent before it is distributed, to save recipients having to enter obvious data themselves (e.g. address of organization). However, even with this assistance, respondents may have difficulty answering some of the questions, may leave some fields blank, misinterpret questions, or bias answers based on incorrect assumptions.

- **Structured Interviews**

The structured interview uses an independent person to obtain views through direct questioning and discussion. The interview is 'structured' in the sense that there are particular topics and/or questions which are asked in all cases, and standard explanatory information is provided in advance. Interviews may be conducted individually or as a group. Individual interviews can be conducted formally (questions are asked and responses recorded on tape or written down), or informally (questionnaire is used as a guide to discussing key topics). Information can be recorded either at the time or summarized following the interview. The interviewing approach should be sensitive to the cultural norms of the institution and individual concerned. Group interviews are useful where discussion and consultation are the preferred way to establish answers. A questionnaire or check list is used as a guide to solicit and record information. Information from the group is then summarized. In this approach it is useful to have one person to lead the discussion and another to record important information. Group interviews often benefit from a short presentation on the topic before opening up the discussion more fully.

- **Workshops and Working Groups**

Working groups (sometimes known as task forces) are small teams of individuals formed to address specific topics and return their results in a specified time frame. Working groups differ from more formal groups in having a time-limited mandate—i.e. no further role after the assigned task is complete. Working groups are usually composed of experts in particular fields rather than representatives of organizations. Working groups are a particularly useful way to refine information on a certain topic (e.g. a working group on indicators, or GIS) or to resolve serious problems or uncertainties.

- **Workshops**

Workshops are similar to working groups in having the objective of addressing a particular—perhaps wide ranging—topic. A workshop brings together relevant expertise for a short period (usually 1 to 5 days) with the aim of achieving agreement, better mutual understanding of issues, and a plan for future action. Workshops often incorporate elements of training and, where a wide spectrum of institutions are involved, facilitate sharing of knowledge and expertise. To maintain objectivity in discussions, external facilitators may be brought in to some or all parts of a workshop. Their role is not to lead participants to conclusions but, rather, to help arrive at decisions by consensus.

- **Brainstorming**

Brainstorming is a particular type of discussion technique in which the goal is to accumulate ideas on a subject in a short space of time. A facilitator is needed to initiate and steer the session, as well as create an atmosphere which stimulates creative thought. In a brainstorming session, all individuals are free to speak, and there is particular encouragement to put forward unusual and new approaches. All inputs are recorded. The ideas are then sorted and used where applicable in the context of the project. Brainstorming is most useful when defining the initial scope of a project, when a change in strategy is required, or simply for an infusion of new ideas and inspiration. For example, brainstorming may be useful in trying to identify key datasets in an institution, or new forms of information products to influence decision-making.

4

INFORMATION PRODUCTS

INTRODUCTION

The assessment of information needs results in a description of areas in which it is cost-effective to produce information. However, in order to maximize the impact of information on decision-making it is important to understand the constraints under which decision makers operate—and refine information accordingly. For example, decision makers are often busy and have little time to process large amounts of data or apply themselves to difficult interpretation tasks. This chapter examines how to design the ideal information product and how to determine which datasets are necessary to build it.

Decisions often rely upon a good understanding of just a few key facts and issues at any point in time. The implication is that information should convey simple, succinct messages which clarify otherwise difficult decisions. With issues competing for attention in an information-crowded world, timeliness is also a vital consideration in determining the usefulness of information. Even the simplest, best presented information will have little impact if its message is released too late.

By emphasizing presentation issues such as clarity, timing and method of delivery, information products address these constraints. They make information both useful and usable by its intended audience, bridging the gap between science and policy by attempting to transfer scientific ideas into policy-making. Box 4 summarizes the design factors which characterize good information products.

Box 4: Characteristics of a good information product

- Designed for a specific audience.
- Relevant to decision-making needs.
- Available when the 'window of opportunity' for decision-making arises (i.e. timely).
- Easily and quickly understood.
- Based on sound scientific principles.
- Delivered through recognized channels.
- Areas of uncertainty and their significance clearly identified.
- Accompanied by full acknowledgement of data sources and intellectual property (an 'audit trail').
- Available at minimal cost in terms of time, money and administrative overheads.

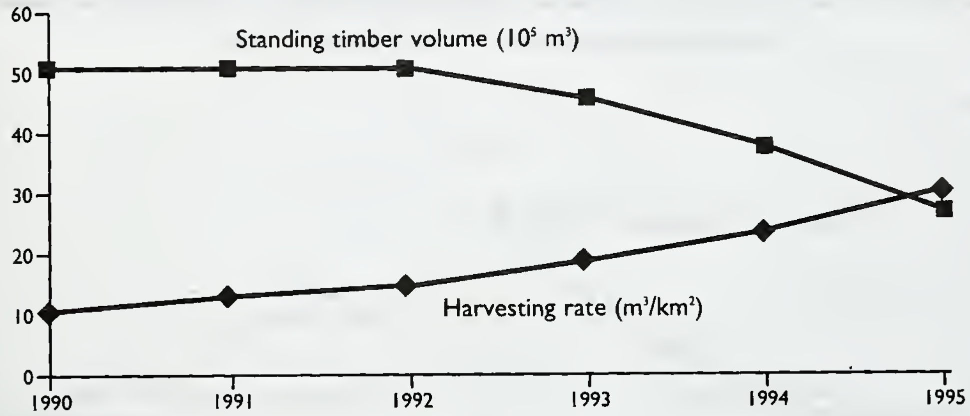
Information products are traditionally prepared as reports, maps, papers, pamphlets, brochures and other forms of publication, including video, audio, slides and posters for large audiences. As well as content, good publications attend to a range of structural and layout issues. For instance, reports should be structured logically, with a well defined beginning, middle and end; a brief summary should be included at the start (e.g. an 'executive summary'); detail should be consigned to annexes, less visible areas, or completely left out; and 'navigation' aids should be provided, such as tables of contents, lists of figures, page numbering, references, and an index.

With respect to layout, publications should contain clear, simple information, with plenty of space and features surrounding the body of the message. Ideally, they should be presented with attractively designed pages which guide the reader through the information presented. Judicious use should be made of shading, colour, and fonts, as well as diagrams, tables, maps, charts, graphs, photographs, images, and other 'features', to enhance key messages and break up text. Boxes containing summaries or supplementary text add further value, and examples and case studies help to reinforce key points.

Even the most expertly designed information product will fail to achieve its goal unless attention is also focused on another key area: marketing. There is a growing abundance of publicly available information in the world and

information users of all kinds are finding it increasingly difficult to discriminate between sources. Marketing helps persuade users that it will be cost-effective to use the information in question.

Figure 5: Example of an information product



There is much to learn from the publishing industry in this regard. For example, it is unlikely that a commercial publishing company would neglect to market its books or journals properly. Such companies understand that, unless a product is advertized, attractive, easily available and promotes its content, it will not reach its maximum potential audience. Thus, making sure that information is professionally produced, that it is available without heavy cost or bureaucratic hurdles, and that its anticipated users are fully aware of its existence and availability (if not its detail), all help to increase its overall impact.

One group of information products which deliberately focus on design and marketing issues are known as indicators. These are time-varying measures of policy performance, accepted as reliable by many sectors of society. Well known examples from the financial domain include the Dow Jones and FTSE indices from Wall Street (New York) and the City of London respectively. The frequently used GNP and GDP figures estimating nations' economic performance are further examples. In the case of biodiversity, the development of indicators enables governments and other groups to measure progress towards sustainability targets in a fully transparent manner (see Hammond *et. al.* 1995 for a detailed discussion of environmental indicators).

Figure 5 is an example of a simple information product drawing attention to diminishing stocks of timber in a natural forest reserve. The graph showing the decline in standing timber volume (i.e. the 'state' of the resource) clearly illustrates the downward trend; the graph showing harvesting rate (i.e. the 'pressure' on the resource) indicates why this might be happening; and the two graphs together suggest an appropriate solution (i.e. limit harvesting rate to 1992 level which appears to be sustainable).

In order to clarify what management responses are necessary to combat identified pressures, trends can be annotated with performance targets and thresholds beyond which practices are considered unsustainable or hazardous respectively. Figure 6 illustrates the addition of performance targets for timber harvesting which, if achieved, return harvesting to a sustainable level over five years.

DATA NEEDS ANALYSIS

Figure 7 illustrates the life history of an information product in the form of an 'information pyramid'. The transition from primary data (as collected by survey or monitoring activities) to information product is one of data integration, analysis and publishing. Interpretation and synthesis occur at each higher level of the pyramid until the information is ready to be delivered to its audience. Depending on which interpretation techniques are applied, multiple products can be derived from the same primary data—each forming a separate pyramid aimed at its own particular audience.

Figure 6: Example of an sustainability target

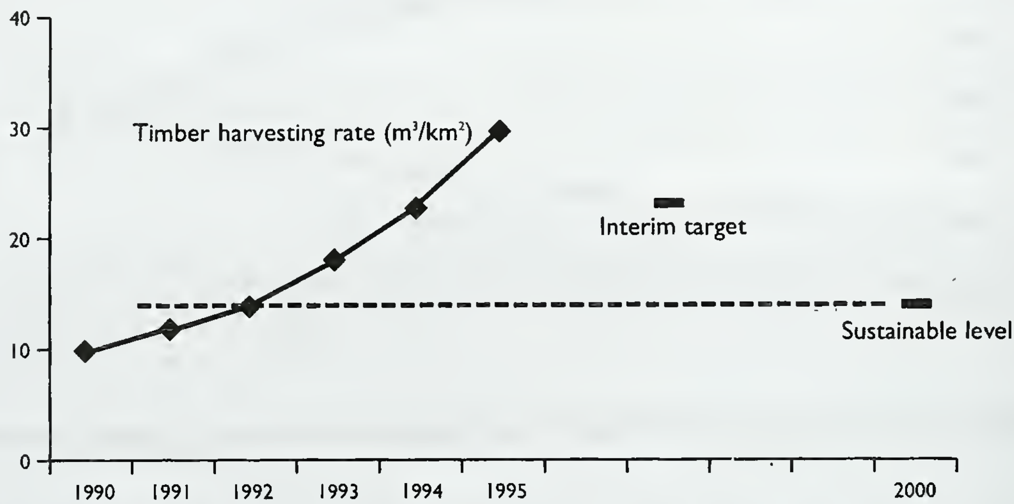


Table 1: Data needs analysis

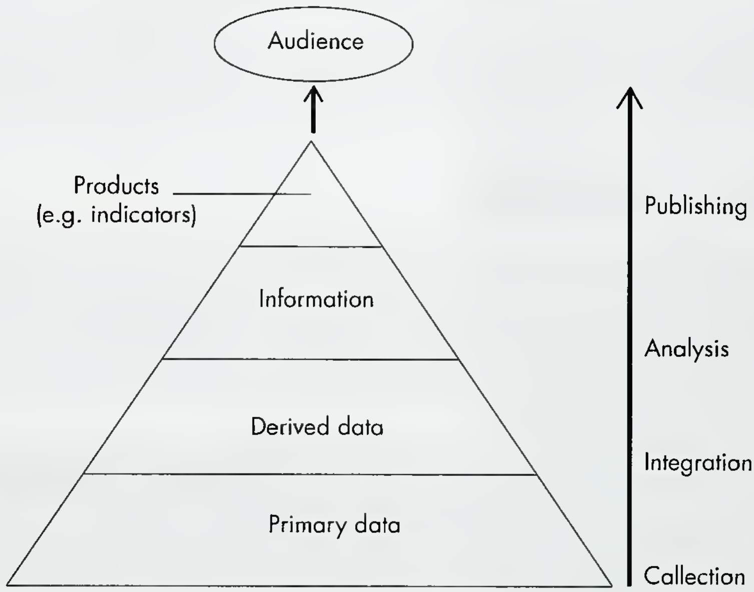
Issue	I_1	I_2	I_3	...
Information needs	N_1 N_2 N_3	N_4 N_5 N_6	N_7 N_8 N_9	...
Data needs	D_1 D_2 D_3 D_4	D_3 D_5 D_6 D_7	D_2 D_3 D_5 D_6	...

overlap

The information pyramid portrays a 'bottom up' process in which primary data are transformed into information products to support decision-making. In practice, products are developed in the reverse direction: the necessary datasets for a product (i.e. its data needs) are traced back from the information needs it is trying to address. Thus information needs dictate data needs, not the other way around.

The process of distilling data needs from information needs is illustrated in Table 1. In this analysis, each issue demanding an information product (denoted with the letter I) is broken down into a series of information needs (denoted with the letter N); and each of these is broken down into a series of data needs (denoted with the letter D). Clearly, each issue gives rise to a separate information pyramid, focused at a specific audience.

Figure 7: The information pyramid



Although the issues (and products) may be quite different, many of the datasets which underpin them will be in common. This suggests that real efficiencies can be gained by stakeholders developing and exchanging essential datasets collaboratively. Indeed, since stakeholders may depend on certain essential datasets to produce information, differing priorities can be given to their development (i.e. upgrading or building from scratch).

To put it very crudely, a higher priority would be accorded to those datasets which are essential to the development of multiple information products. A good example is a spatial dataset containing the national boundary. Without this, stakeholders are unable to conduct almost any spatial analyses at the national level.

Table 2: Prioritising data development

Dataset	D_1	D_2	D_3	...
Priority	low	medium	high	...
Current status	non-existent	actively managed	under development	...
Development tasks	build from scratch	update	update, extend, validate, document	...
Lead stakeholder	S_4	S_1	S_7	...
Partners	S_1 S_5	S_4	none	...

Table 2 illustrates a method for prioritising data development activities. A development priority (low, medium or high) is accorded to each dataset (denoted with the letter D) discovered to be essential to address at least one major

issue (see Table 1). The current status of each dataset is then described, and remaining data development tasks outlined. Finally, the lead stakeholder (generally the custodian—see Chapter 5) coordinating the development of the dataset is indicated (denoted with the letter S), and its partners listed.

Clearly, a more rigorous approach would be taken in practice. However, as a whole, the method provides all the necessary information to commission high efficiency data development activities—capable of serving the interests of many stakeholders simultaneously. The way in which these activities are implemented is the subject of the next chapter.

PRODUCT DEVELOPMENT

Before developing an information product a design specification should be prepared. Depending on the anticipated time required to develop the product this may vary in size from a short summary to a detailed project proposal. The design specification contains an overview of the biodiversity issue being addressed; a description of the benefits of the proposed information product; recommendations on its content, format, timing and method of delivery; details of the lead agency intending to coordinate development of the product; details of other stakeholders involved; and an indicative budget and schedule.

The design specification may also contain technical details such as an inventory of essential datasets; a survey of current data availability and quality; diagrams illustrating how data will be exchanged between stakeholders; an indication of who will lead development of essential datasets; and descriptions of data analysis or interpretation techniques which will be applied. The specification is conceptual in nature and, thus, independent of how the information will be generated physically (e.g. the manual or computerized techniques which are applied).

Depending on the availability and quality of essential datasets, the time required to develop an information product can be measured in weeks, months or even years. For instance, the development of a protected areas policy may require a map illustrating areas of conservation importance, which might depend, in turn, on the existence of a national-scale vegetation dataset. If this is out of date, unreliable, or developed at the wrong scale, the development of the conservation areas map might be delayed until it has been re-drafted.

Similarly, the degree to which stakeholders are able and willing to cooperate (organizational readiness) can affect the time-scale of product development significantly. Potential constraints include difficulties in accessing data between stakeholders, use of incompatible data standards, concerns over data quality and limitations in human, technical or financial resources (see Chapter 6). Box 5 distinguishes three categories of information product deliverable over increasing time-scales.

Far-reaching, strategic products may take several years of collaboration to develop. To overcome the fatigue which can occur during the development of such products, one solution is to evolve them as a series of immediate and interim products which justify participation by demonstrating progress. This approach, which follows the continuous improvement management paradigm, requires extensive communication between stakeholders to ensure that efforts are sustained in a strategic direction.

Box 5: Categories of information product

- Immediate (3 months): no constraints; product development can begin as soon as resources are allocated.
- Interim (6 months—1 year): minor constraints; some data development or stakeholder organization required; product development can begin following removal of these constraints.
- Strategic (> 2 years): major constraints; essential datasets unavailable; further research required; stakeholders not organized to respond; product development on hold until data become available, research findings published or stakeholder organization complete.

5

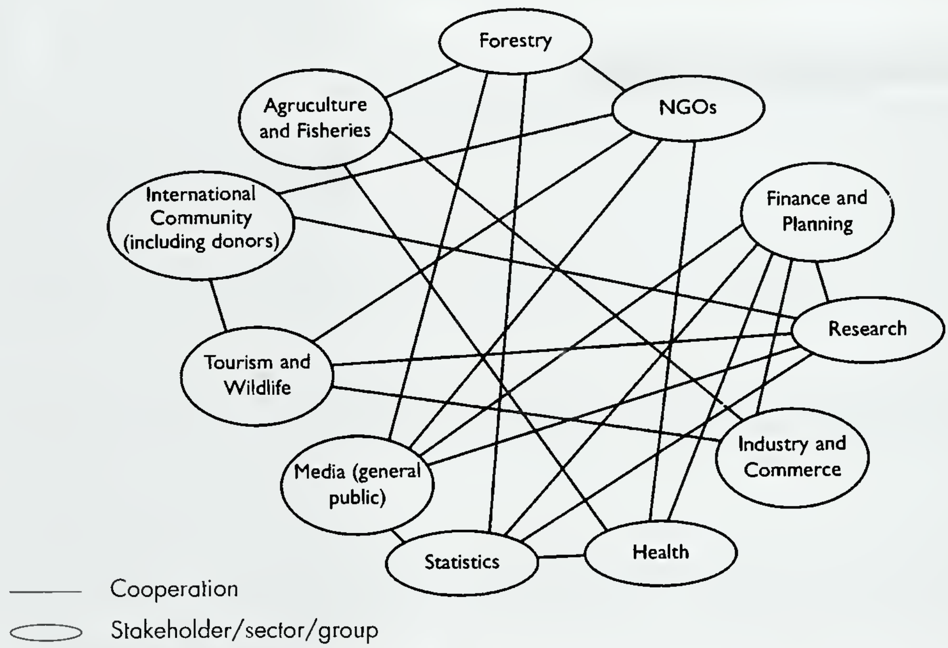
STAKEHOLDER ROLES

INTRODUCTION

Almost all organizations benefit from data managed by others. For instance, forestry department maps may be employed by a local government administration to resolve a land dispute, and human population figures managed by a national statistics department may be used by planners in the agriculture and health sectors.

Access to data has an empowering effect on recipients which, for lack of expertise or resources, they might not have been able to achieve otherwise. The providers also benefit in that they gain credibility in providing a service to others and, in the process, build relationships which enable them to maintain their data. It is clear that data sharing is a classic 'win-win' situation in which organizations—whether they are providing or receiving data—become empowered by the exchange.

Figure 8: Fully distributed network



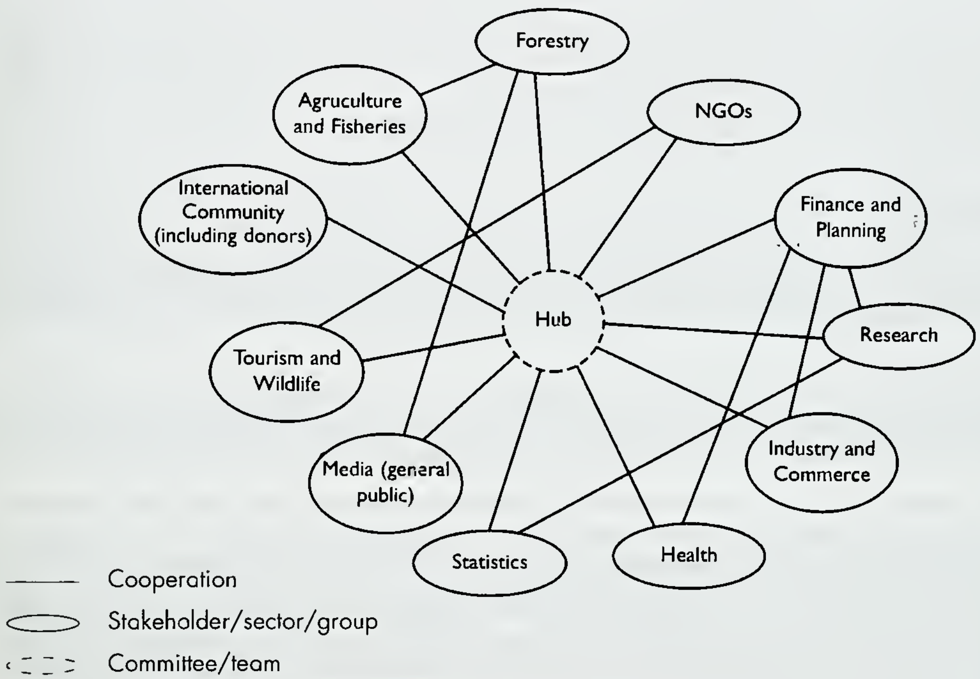
However, gaining access to essential data can be difficult and expensive, even from within separate parts of the same organization. One reason is that data exchange is sometimes viewed as prejudicial to an organization's interests, or even dangerous. Hence it can be frustrated by political, organizational and even personal barriers.

This chapter explores how stakeholders can organize themselves to implement the information cycle introduced in Chapter 2. The chief objective is to minimize the barriers to data exchange so that data are mobilized for conservation and sustainable use of biological resources. The rewards are great: the ability of organizations to fulfil their core responsibilities is enhanced; opportunities are generated by empowering organizations to take on new roles; and information products can be developed with wider support and with greater efficiency.

INFORMATION NETWORKS

The people, data, tools and processes used to build information products are collectively referred to as an information system. In cases where multiple stakeholders are involved, a more precise term is multi-stakeholder information system, information network or, simply, network. Examples of biodiversity networks occur throughout the world and are increasing in scope and effectiveness (see Chapter 7).

Figure 9: Clearing-house network



Biodiversity networks tend to establish themselves in similar ways. The initial push is from community groups, professional associations, and individual scientists who are often the first to notice or measure changes in biodiversity status. As awareness is raised, informal scientific networks are established to harmonize activities such as data collection and data exchange. These often depend upon the resources of a single institution or source of sponsorship to survive and, thus, tend to form and dissolve according to the availability of resources. Eventually, however, increased size, prominence and acceptance by decision makers can enable them to grow into self-supporting bodies which are recognized or even adopted by governments. Not all networks develop in this way: some may be initiated directly by governments or indirectly via externally sponsored projects.

Occasionally, decisions to develop biodiversity information have been used to justify the centralization of data sources in a single location. Whilst this is efficient in certain restricted cases[4], it is unsustainable in multi-stakeholder situations where, quite correctly, stakeholders expect to retain full control over their data. Since this includes the ability to continue managing data at their own premises, a distributed rather than centralized architecture is most common (see Figure 8).

However, recognizing that network productivity depends on extensive cooperation, the fully distributed architecture has one major disadvantage: it lacks a mechanism for coordination. Figure 9 illustrates how this can be rectified by

[4]Centralized data management is suitable in cases where stakeholders do not have the capacity to manage data themselves, stakeholders all occur within a single organization where individual feelings of data ownership are subsumed by corporate objectives or, for security reasons, data are more securely managed from a central location.

the addition of a central coordinating hub[5]. This produces what is referred to as a 'clearing-house' architecture (WCMC 1994). Note that the hub is drawn with a dotted line to convey its representative nature: it may be, simply, a committee of stakeholder representatives with appropriate administrative support (see below—Role of the Hub).

The hub differs from other stakeholders in the network by focusing on services rather than data (i.e. a facilitating role). For instance, in addition to its primary role of coordination, the hub facilitates access to data, identifies priority information products, and brokers financial investments—services which 'enable' stakeholders to cooperate more efficiently. It should be noted that, despite the presence of the hub, the network remains driven by stakeholder participation. Indeed, as we shall see later in this chapter, the hub may consist of a small group committee of stakeholder representatives.

In a distributed architecture, the network is the system. This conveys the principle that the system producing biodiversity information is a collection of participating stakeholders rather than a particular programme, project or item of technology. The benefits of collaboration (e.g. access to data, attraction of investment, efficiencies in information production) are therefore felt by many stakeholders, rather than by one or a few only. Ties between stakeholders are also fostered, leading to mutual improvements in organizational security and performance.

CUSTODIANSHIP

A key function of the information cycle (see Chapter 2) is the design and development of information products for decision-making audiences. Management responsibility for the essential datasets underpinning the products needs to be very clear, therefore, particularly when the latter are required to support nationally important policy objectives.

Stakeholders who manage essential datasets and, more importantly, are trusted to do so, are referred to as the 'custodians' of those datasets[6]. This title is invested with a host of responsibilities, such as making sure that the dataset is up to date, documented, and maintained in such a way that it is accessible to others. Custodians also have rights, such as the ability to set conditions on access to the dataset and recommend proper ways in which it should be used.

Every dataset—and this is especially true of essential datasets—should have one and only one custodian. The concept is very practical: it makes the responsibility for managing a dataset explicit, helping to ensure that its quality and accessibility are maintained. Without an agreed custodian, management responsibility can be duplicated or, worse, absent.

Custodianship can be applied at all levels. At the national level, responsibility for data themes is usually allocated among government departments. For example, land infrastructure such as administrative boundaries, topography, settlements, roads and rivers might be assigned to a department of survey and mapping. At the agency level, responsibility for specific datasets may be allocated to sub-departments, units, or other recognized groups. Similarly, within such groups, individuals assume responsibility for maintenance and development of sub-components, or entities, of a dataset.

A distinction should be drawn between data themes and datasets (Busby and Walton 1994). A theme, such as topography, can consist of a large number of diverse datasets. Responsibility for the theme could be allocated, for administrative reasons, to one specific stakeholder. That stakeholder may then assume custodianship for one or more topographic datasets. However, such an administrative arrangement must not prevent other stakeholders from developing topographic datasets to meet their own requirements—and for which they would wish to become custodians. A good example is the defence forces wishing to develop a vegetation dataset to enable them to plan heavy vehicle exercises. The attributes needed for that task would be different from almost all other stakeholders. Thus they would develop and manage that dataset and, assuming that security was not an issue, make it accessible to other stakeholders.

It is accepted that environmental data are not easily categorized and overlap in jurisdiction can easily occur. The way forward is to designate one stakeholder the overall custodian of a dataset and allow other stakeholders to manage sub-components (entities) of the dataset. An example would be a species dataset held in a protected areas management agency. Data on the distribution and economic value of the species are held by the protected areas management agency, but the list of names used to reference the species may be managed by a more specialist custodian such as the local museum or herbarium.

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[5]For clarity, few one-to-one linkages between stakeholders are illustrated. However, stakeholders are free to develop one-to-one ties in addition to their link with the hub; the architecture of the network is designed to encourage communication, not restrict it.

[6]Not all stakeholders will be custodians since some may contribute complementary services such as influence, contacts, training, or physical and financial resources.

THE ROLE OF CUSTODIANS

The capacity of a network to develop information products depends on how well essential datasets are managed by custodians. Thus, in agreeing to be the custodian of a dataset, certain responsibilities are implicitly accepted (see Box 6).

Box 6: Responsibilities of custodians

- To undertake routine maintenance of the dataset (e.g. keep it up to date, ensure that it is backed up, perform necessary changes in structure and content).
- To ensure the quality of the dataset (e.g. adherence to standards, provision of documentation, audit trail, validation).
- To advise on appropriate uses of the dataset (e.g. recommended/improper/unwise/forbidden uses).
- To provide cost-efficient access to the dataset.
- To coordinate the development of the dataset (perhaps with other stakeholders).

It is in the best interests of custodians, as well as collaborating stakeholders, to assume these responsibilities. Each contributes to the well being of a dataset, which leads to internal productivity gains as well as an increased capacity to collaborate with others. However, custodians may be concerned at the prospect of others accessing their data. For this reason, custodianship is also invested with certain rights (see Box 7).

Box 7: Rights of custodians

- To regulate access to a dataset (e.g. to avoid inappropriate commercial use or the possibility of placing biodiversity at risk).
- To safeguard their intellectual property (e.g. acknowledgement by users, controls over copying and distribution).
- To receive feedback from users on future needs from the dataset.

The provision of rights (such as the ability to regulate access to a dataset) is not intended to prevent legitimate use of a dataset; indeed, the aim is to foster an environment in which data exchange is straightforward and encouraged. Above all, custodians must feel comfortable providing data to others, and data users (custodians and non-custodians alike) should be satisfied with the data they receive.

Normally, custodianship of a dataset is accepted by the organization most familiar with its history, special management requirements and potential uses. In many cases this organization will be obvious to stakeholders, allowing custodianship to be confirmed without issue. However, where several organizations claim custodianship a representative group (e.g. the hub) may decide to undertake a review. This could be done on a dataset-by-dataset basis or, alternatively, as part of a network-wide review of custodianship.

It should be appreciated that, ultimately, environmental datasets are significant to a wide range of stakeholders, not just their custodians. This suggests that wider, perhaps national needs should prevail over individual feelings of data ownership, particularly in the case of essential datasets which are depended upon by stakeholders for projects of

national importance. Difficult decisions may have to be made in the short-term to guarantee the quality and accessibility of a dataset in the long-term.

As with all decisions of this nature, it is imperative that they are arrived at transparently and with the full participation and consensus of leading stakeholders. Box 8 lists a variety of criteria which can be used to determine which stakeholder is the most appropriate custodian for a particular dataset (note that the criteria are not equally important).

Box 8: Potential criteria for selecting custodianship

- Statutory responsibility for data collection (beware of overlapping mandates).
- Historic responsibility for data collection.
- Greatest operational need for the data (e.g. for decision-making).
- First to record changes to the data.
- Most 'competent' to manage the data (e.g. productivity, efficiency, resourcefulness).
- Track record (confidence of users).
- Requires the greatest level of data quality (e.g. military precision).
- Best financial resources (beware short-term effects).
- Most physical resources (e.g. space, equipment).
- Most stable (e.g. dependable support, long-term future, least staff turnover).
- Most impartial (i.e. no 'conflict of interest').

A crude way to determine the most suitable custodian is to select the criteria thought to be most useful in the local context and attach numeric 'weightings' to each criteria depending on their perceived relative importance. This allows potential custodians to be 'scored' as illustrated in Table 3 (the letter C denotes custodians). Results generated in this way provide insufficient means to assign custodianship in their own right, but may form a useful basis for discussion.

Table 3: Analysing custodianship

Criteria	Weighting	C_1	C_2	...
statutory responsibility	5	✔		...
historic responsibility	1		✔	...
greatest operational need	3	✔		...
first to record changes	2	✔		...
most 'competent'	2		✔	...
best track record	4		✔	...
...	...	...	...	...
Score		10	7	...

THE ROLE OF THE HUB

Coordination is the greatest challenge of the hub, since without this the desired benefits of collaboration will not be realized. The primary role of the hub is to facilitate information generation by stakeholders. Within this role three main services can be identified: to promote dialogue between stakeholders, to assess their capabilities and needs, and to enable them to implement the information cycle (see Box 9).

Box 9: Potential services of the hub

- To promote dialogue between stakeholders in the form of meetings, workshops, correspondence, newsletters, and other forms of exchange.
- To assess the capabilities and needs of stakeholders in terms of data, expertise and technology and, where necessary, propose efficiencies and arrange investments.
- To enable stakeholders to implement the information cycle (i.e. arrange teams to prioritize biodiversity issues, determine information needs, develop essential datasets, develop information products, and facilitate adoption of standards and data access agreements).

A number of supplementary services are also valuable, such as redirecting enquiries about network activities to the appropriate stakeholder (i.e. clearing-house function), holding copies of key information products and publications for distribution purposes, and maintaining backup copies of essential datasets for increased security.

The success of the hub can be judged by the extent to which the collective objectives of the network are met. Good performance indicators are the number and quality of information products delivered to decision-making audiences and, ultimately, the positive effects on biodiversity which can be demonstrated. Clearly, the hub will be most successful if it is perceived to be acting in the best interest of stakeholders. One way of ensuring this is to have the hub steered by a committee of stakeholder representatives who, as a group, help arrange technical teams to implement the network's objectives. An efficient organizational structure for the hub comprises two components therefore:

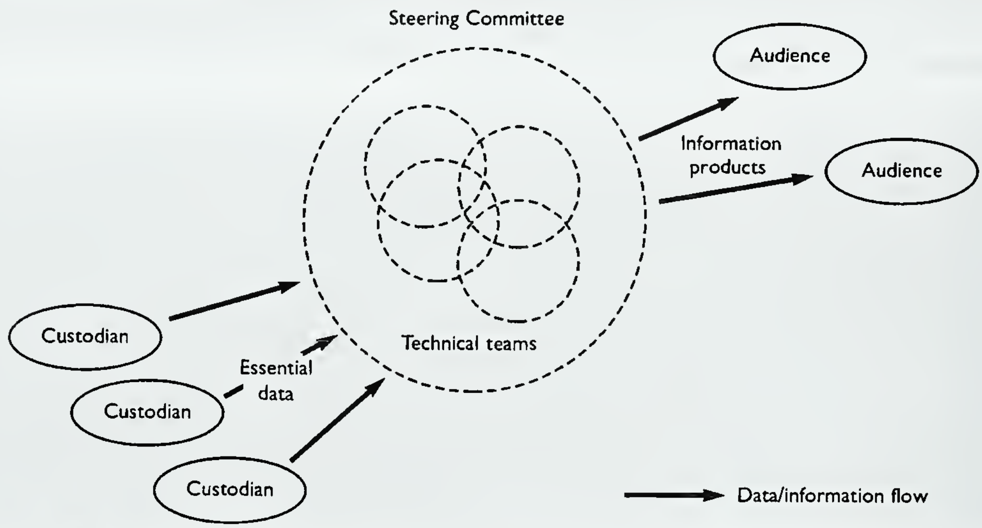
- **Steering Committee**

  A high-level committee representing the interests of major stakeholders, the Steering Committee brings leadership and authority to the network. Its role is to set policies for the network, manage custodianship, facilitate good relations and working practices between network partners, and help form technical teams (task forces) to fulfil agreed information goals. Consisting of senior and respected individuals, the Steering Committee provides an influential front to the network's activities.

- **Technical teams**

  Under the umbrella of the Steering Committee, technical teams are formed to fulfil specific objectives such as shortlisting biodiversity issues demanding information, determining the information needs of decision makers facing these issues, designing information products, and developing essential datasets. Clearly, teams are dynamic: they are formed, complete their goals, and terminate.

Figure 10: Operation of the hub



Team composition will vary according to what objective is being met. For instance, a team shortlisting priority issues might be composed of senior representatives from major stakeholders, whereas teams building information products might consist of technical representatives from relevant custodians. In general, teams are not drawn from any staff which may be employed by the hub, but from the pool of expertise available throughout the network.

The purpose of this two-tier arrangement is to separate organizational processes from technical processes. The former involve issues such as resource allocation, transparency, jurisdiction over data and services, management of custodianship and the legal implications of data exchange, whereas the latter concern data development and information production (which may involve the application of information and communication technologies). Unless the organizational issues are dealt with an appropriately high level, technical teams may find themselves overburdened with unforeseen challenges.

Theoretically, the hub does not require a permanent base from which to operate since it consists of a committee (which can meet anywhere) and a series of technical teams working with individual custodians. However, for administrative reasons a base is necessary to provide good communications and office facilities. Figure 10 illustrates how the hub—through the formation of technical teams—helps custodians combine their data into information for target audiences.

The hub does not need to manage biodiversity data itself, since this is the responsibility of custodians. However, to ensure that technical teams are composed of the right staff and that they are provided with urgent and realistic goals, the hub may wish to assume custodianship of one particular theme: stakeholder capacities and needs. This theme consists of several datasets, as indicated in Box 10.

Box 10: Useful datasets for the hub

- **Stakeholders**

  Contact details, summary of core business as it relates to biodiversity, major partners, information management capacities and needs (human and technological) and data needs.

- **Datasets**

  Custodian, current status, intended uses and access conditions (see Chapter 6—Data Access). Relevant international datasets could be included. This type of data is often referred to as metadata, since it is, literally, data about data (see Chapter 6—Data Quality)

- **Sources of support**

  National and international sources of development assistance (e.g. financial support, technical assistance and other facilitation services).

The main reason for managing such data is to enable the hub to provide better facilitation services to stakeholders. Without a good understanding of their perceived roles, strengths and weaknesses, it is difficult for the hub to coordinate efforts and focus investments efficiently. This important topic is discussed fully in the companion document, *Guide to National Institutional Survey*.

6

MOBILIZING DATA

INTRODUCTION

Having agreed priorities for information production and established an organizational structure to manage cooperation, the final stage of the information cycle is to enable stakeholders to fulfil their agreed roles. This may be hampered by constraints in human or technological resources, funding, or coordination, particularly when stakeholders are collaborating on information production for the first time and joint operational procedures have yet to be fully established.

In such circumstances, cooperation can be facilitated by addressing key concerns such as data access, data standards, data quality and data flexibility, which serve to *mobilize*[7] data for ready use within the network. The judicious application of information technology can also be effective (see Chapter 7). Attention to these areas helps strengthen working relationships between stakeholders leading to more efficient information production.

One of the most important roles identified in the previous chapter is that of custodians who are trusted to maintain and provide access to essential datasets. This chapter explores their concerns and offers guidance on how to manage and exchange data for maximum productivity. The concerns comprise:

- **Data access**

  Data access agreements are helpful in situations where stakeholders are concerned about the potential exploitation, misuse or quality of a dataset. As confidence grows the need for formal agreements diminishes.

- **Data standards**

  Data should be collected, managed and exchanged following accepted standards (conventions) to reduce costs of data exchange and facilitate comparison of results in space and time.

- **Data quality**

  The quality of a dataset is a measure of its fitness for use for a specific purpose. Two important aspects are data quality assurance and dataset documentation, which enable stakeholders to use data reliably and cost-effectively.

- **Data flexibility**

  To ensure that data remain flexible (i.e. can be used for multiple purposes), they should be collected and stored in their primary form, not classified, aggregated, or otherwise interpreted.

DATA ACCESS

Since their operation depends on access to data managed in numerous locations, information networks built on the principle of custodianship will have distributed architectures. This is especially true of networks serving multi-disciplinary topics such as biodiversity. Thus a key role of the hub is to enable stakeholders to realize the benefits of data exchange, which comprise value to the recipient through access to essential data; credibility to the provider for being of service (paving the way for future exchanges and access to value-added products); and increased trust and cooperation between stakeholders (adding to their long-term security and creating opportunities).

However, both custodians and users may have legitimate concerns over data exchange, as described in Box 11. Concerns may be held at all levels, from individuals through to governments. Unless addressed fully they have the potential to hinder data exchange and, as a result, reduce interest in collaboration. One way forward is to accompany data transactions with formal agreements signed by both parties, offering tangible assurance that concerns on both sides have been satisfactorily addressed.

Data access agreements are perceived to be difficult to negotiate, but this need not be the case. A useful step is for the hub to draft a generic data access agreement for distribution and adaptation by custodians. In the interests of simplicity, agreements should assume goodwill on the part of users, not bad faith. Thus administrative, cost and other restrictive clauses should not be included unless absolutely necessary. Example components of a data access agreement (regulating access to specific dataset) are presented in Box 12.

[7]This involves managing data in ways which promote its accessibility and use. For instance, data should follow standards wherever feasible, be well documented, and, preferably, be available in a standard electronic format.

Where goodwill on the part of users does not exist, then access to a dataset may be denied by the individual custodian or the network as a whole. For instance, the hub could advise stakeholders of the existence of certain users (both national and international) who have a history of exploiting data; similarly, they could advise users of the existence of poorly performing custodians.

Data access agreements should not be viewed as a defensive measure intended to limit data exchange. They are a positive measure to increase trust between cooperating stakeholders. As confidence grows, the need for formal agreements diminishes until, ultimately, they should no longer be required.

Box 11: Typical concerns over data access

Concerns of custodians:

- Will costs be covered?
- Will the dataset be used correctly?
- Is the exchange consistent with internal and network policies?
- Will use of the data be appropriately acknowledged?
- Could credibility suffer (e.g. where data are poor quality or where inappropriate use may reflect badly on the custodian)?

Concerns of users:

- Is the dataset fit for its intended purpose?
- Will it be available (perhaps regularly) on time?
- Will onerous conditions be imposed?
- Is it accessible in a standard format?
- What, if anything, will it cost?

In many countries there are laws and regulations governing the duplication or exchange of data in certain forms. Thus copyright laws restrict the duplication of text, designs and maps, and patent laws control the exploitation of ideas. In general, such laws aim to protect the legitimate rights of those producing original works, whether these are paintings, inventions or environmental data, helping to ensure that the correct credit for original work is recognized. In some cases this may be essential to the core business of an organization or the reputation of an individual.

Copyright affords some protection to a dataset in its permanent form, independent of how the data are disseminated to others (e.g. in writing, illustration, broadcast etc). The extent of protection varies among jurisdictions. The originator can assign or license copyright to another individual or organization, provided agreement is made in writing. However, the 'moral rights' (such as the right to be acknowledged in publications and the right not to allow unauthorized alteration or misrepresentation) remain with the originator. Thus an individual or organization wishing to change a biological dataset must have written permission from the copyright holder (Burnett *et al.* 1995).

Networks of cooperating stakeholders present a special legal challenge since they thrive—indeed, depend—on data being used by many stakeholders. Legal issues relating to data exchange within such networks are largely unresolved. The lack of an appropriate framework can be turned to the network's advantage, however, since the best solution is to build goodwill, trust and fair dealing—principles which are of immense value to all aspects of the network's functioning. This spirit of cooperation should be encouraged by the hub, which can also take responsibility for resolving misunderstandings which occur.

At the international level, the exchange of data and information on biological resources may impinge on legal and conceptual views of sovereignty and security, particularly where the information concerns government policies and legislation. It is clear that concerns over the misuse of information for strategic or political purposes must be addressed before the desired level of exchange will be achieved.

Box 12: Potential components of a data access agreement

- **Access conditions**

  Different conditions may be applied to different classes of user (e.g. government, NGO, research, commercial); for instance, immediate access may be granted to governmental users, conditional access to NGOs and research users, and no access to commercial users.

- **Transaction costs**

  Transactions can be costed in a variety of ways; for instance, totally free, free to reciprocating users only (barter), cost of supply (i.e. immediate access costs), incremental cost (i.e. taking into account maintenance/depreciation), cost of development (i.e. taking into account the initial costs of building the dataset), or 'market value' (the maximum cost which the user will pay). The flow of data within networks is encouraged when cost barriers are as low as practicable.

- **Permitted/excluded uses**

  Custodians are responsible for advising users on the potential uses of a dataset. They may also recommend specific permitted uses or, conversely, excluded uses of a dataset. This may occur when, for example, the custodian believes the data are unsuitable for certain purposes due to uncertainties or ambiguities in the dataset. It also provides a means for custodians to safeguard their intellectual property and credibility.

- **Distribution to third parties**

  Unless a custodian provides explicit consent, users should not copy data onward to third parties. Instead, third parties should be referred to the custodian so that proper consent can be arranged[8].

- **Acknowledgement of sources**

  Publications, information products and all outputs derived (even in part) from a dataset should acknowledge data sources and intellectual property. In cases where data have been interpreted several times before use, a long list of acknowledgements (known as an 'audit trail') may be necessary. Custodians should advise users on the most effective way to acknowledge their data.

- **Disclaimer**

  In the event of incorrect data being provided, and consequent harm being caused, liability could fall on the originator of the data, its custodian, a third party which has provided the data or all of these. The situation is most serious when 'negligence' is detected, for instance when it is established that data were poorly maintained. The issuing of a disclaimer warning users of any deficiencies which may be present in the data affords some protection against this eventuality (see Onsrud 1989 for a full discussion).

DATA STANDARDS

Standards enable people to communicate with each other in recognizable ways: languages are a good example. In the present context, standards refer to agreed methods of collecting, structuring and communicating data between stakeholders. The chief purpose of standards is to lower the transaction costs of using data. Thus, in the same way that a common language enables individuals to cooperate more efficiently (thus more cheaply), data standards enable organizations to access and use data more efficiently.

[8] This is particularly important where the public release of data could be damaging to the custodian or, worse, biological resources could be placed at risk.

Without agreement on data standards stakeholders tend to employ different methods of data collection and management which, because of those differences, complicate integration of the data at a later stage. Even within an organization methods may be applied inconsistently by different groups or at different points in time. One of the main advantages of data standards is that they facilitate comparison of results in space and time, and between stakeholders. This is essential for the study of many environmental phenomena which, due to their incremental nature, reveal themselves over long periods of time. One-off studies have their place but consistency of data is almost certainly more useful in the long term.

Data standards have another advantage: like the storage of primary data, they increase the range of applications for which data can be used. If data are available in standard formats based on standard collection methodologies, users can absorb them more easily into their work. However, if standards are not applied data may be perceived as incompatible, inappropriately focused or otherwise unusable.

Agreement of data standards is a time-consuming, largely intellectual activity requiring concrete and determined action—facilitated by the hub—to succeed. However, there is no other realistic way of reducing transaction costs; standards cannot be overlooked, taken for granted, nor left to specialists who are not fully representative of stakeholder interests.

Information networks provide an opportunity to reconcile existing standards—and agree new ones—in the interests of mobilizing data for collective information goals. This process can be facilitated by one or more technical teams, arranged by the hub, whose task it is to review and agree standards covering essential themes, and publish them for use by stakeholders. As a first objective, standards for data exchange ('interchange standards') may be sought to help stakeholders structure data in similar ways for distribution. The financial implications of interchange standards are much less severe to custodians than, for example, the adoption of more comprehensive standards covering data collection and management practices.

Recognizing that progress towards formally accepted national (and international) standards can be slow, stakeholders often develop their own, interim standards. The latter, sometimes referred to as de facto standards, are commonplace across many geographic and biological themes, often having arisen to suit particular data collection and management objectives. Wherever possible, interim standards should build on previous standards at the international or regional level, which may be available via international organizations and networks.

DATA QUALITY

The quality of a dataset is a measure of its 'fitness for use' for a given purpose at a given time, and cannot be estimated before that purpose is known. A topographic map series covering a country at a scale of 1:500,000 might be considered 'high quality' for national-level planning purposes, but 'poor quality' for local planning. Thus, when a dataset is requested for a different use than intended, it is important to remember that its quality, and hence fitness for use, is determined by many factors.

The complexity of environmental phenomena often means measurements are uncertain or subject to error. For instance, mis-identification of some species is inevitable in a large-scale inventory of a complex ecosystem—even if the inventory is carried out to the highest professional standards. Similarly, the inference of vegetation type from remotely sensed satellite imagery is rarely 100 per cent accurate. Box 13 details three common forms of deficiency in environmental datasets: limitations, uncertainties and errors.

Recognizing that most environmental datasets contain deficiencies, it is vital for custodians to pass on an understanding of these when a dataset is released for use elsewhere. Naturally, a description of known deficiencies is only one item of information required by users to employ the dataset fully and safely. Indeed, procedures aiming to improve the quality of a dataset can be applied from the moment it is originated to the time it is needed. These procedures are collectively referred to as data quality management, and include two key components: quality assurance and documentation.

Box 13: Common forms of deficiency in environmental datasets

- **Limitations**

  Limitations are structural deficiencies in a dataset which become clear when it is used for purposes other than intended. A good example is the use of a map with inappropriate scale.

- **Uncertainties**

  Uncertainties are introduced when variables are measured against a non-objective standard, for instance when an area is classified as belonging to a particular habitat type which, itself, may be poorly defined.

- **Errors**

  Errors are introduced when variables are measured incorrectly against an objective standard, for instance when the depth of a lake is recorded with the digits in the number transposed, or with the wrong units.

Quality assurance procedures include the validation, maintenance and upgrading of a dataset in line with accepted standards and expected uses. Policies, judgements and decisions all depend on these procedures being implemented rigorously so that data are kept up to date and, as far as possible, free from errors. Box 14 presents an example of the types of validation procedures applied to species distribution records prior to inclusion in a large national dataset in Australia (Chapman and Busby 1995).

Box 14: Example validation procedures for species data

- Records are checked to see that all required data fields are present.
- Scientific names are checked for validity.
- Grid references of terrestrial species are checked for being over land, not water.
- The presence of a species in a certain location is tested against a prediction based on bioclimatic factors, and outliers selected out for further validation.

In the past, organizations rarely devoted much attention to documenting their datasets. This was because the latter were usually built for one specific project by people who well understood the nature of the data, including its deficiencies. At the end of the project the data were archived, filed or neglected. Thus, although regarded as desirable, documentation was not accorded a high priority because no one believed it would be of much real value.

This has now changed: documentation is now regarded as a strategic corporate asset enabling data to be mobilized for a wider range of uses than previously possible (Medyckyj-Scott *et. al.* 1996). One of the driving forces of this change is the growth of information networks, which depend on stakeholders being granted access to a wide range of data sources, all requiring documentation to use.

Custodians should document their datasets for two important reasons: to increase their own internal productivity by clarifying the function and attributes of their data; and to facilitate access and use by other stakeholders. With respect to the latter, catalogues should be produced giving details of all accessible datasets in the organization.

Such catalogues contain 'data about data' or metadata (in computerized form these are known as a *metadatabase*). Box 15 suggests the potential components of a metadata record. The fundamental principle in metadata development is 'truth-in-labelling'; that is, the dataset should be exactly as described and of a quality which is suitable for its stated—and implied—uses.

Box 15: Potential components of a metadata record

- Title of dataset.
- Contact details of custodian.
- Intended/unwise/improper uses.
- Original sources of data ('audit trail').
- Data collection, management or interchange standards followed.
- Data collection methodology, including personnel, date(s), location etc.
- Data structure ('data dictionary').
- Interpretation techniques applied.
- Quality assurance procedures applied.
- Accuracy/resolution.
- Known limitations, uncertainties and errors.
- Life expectancy (i.e. suggested period of use before update).
- Access conditions/transaction costs.
- Method of access, including available formats and media.

We noted in Chapter 5 that, to deliver its services effectively, the hub needs to know which datasets are managed by which custodians. It is the duty of custodians, therefore, to provide the hub with up-to-date versions of the dataset documentation and catalogues it produces. In return, the hub identifies priority areas for investment and organizes multi-stakeholder technical teams to develop essential datasets and information products.

DATA FLEXIBILITY

Environmental data record phenomena in the physical environment. Some of these recordings are factual, for example the grid reference of the place where a species was observed, the dimensions of a tree, the weight of a log, the mean annual precipitation at a site, or the water retention capability of a soil profile. These are all primary data based on facts which can be measured against a stable, widely accepted standard (Busby and Walton 1994).

Secondary, or derived data (see Figure 7) are those obtained from primary data by a process of interpretation or classification, either at the time of measurement or later. Examples include species name, vegetation type, forest canopy extent, and climatic zone. Derived data should not be stored permanently unless the primary data from which they were derived are also available. This is because, as concepts and paradigms shift, derived data degrade in value and ultimately become useless. For example, if the only representation of a species distribution is an outline drawn on a map, this information becomes redundant if the species is split or otherwise disaggregated following a taxonomic revision. The correct approach would be to store the coordinates of the species observations (and supplementary identification notes) to enable new outlines to be derived.

Primary data are much more flexible than derived data. They can be used for a wider range of applications because they have not been interpreted for a specific function. For instance, daily rainfall measurements in millimetres from a local weather station can be used to assess local climatic fluctuations, fed into national or international monitoring programmes, or integrated with other data to assess the capability of an area to support biodiversity. Primary data of this kind are highly flexible and, therefore, cost-effective to collect. If the rainfall measurements had been classified at source into, say, five secondary categories ranging from very low, low, medium, high to very high, this flexibility would have been lost, resulting in fewer potential applications for the data[9].

[9]The categories may be too coarse or, simply, meaningless in other contexts.

The benefits of storing primary data need to be assessed intelligently. No one, for example, would refuse to store the names of species, even though they are susceptible to change. The process of deciding which type of data to store is one of risk assessment. Given the high costs of collecting and managing data, the benefits of doing so should be balanced against the risk that data will become obsolete or prove to be inflexible.

7

INFORMATION TECHNOLOGY

INTRODUCTION

For information to flow between stakeholders, and from stakeholders to other audiences, data should be managed in ways which promote accessibility. Unlike the previous chapter, which explored organizational approaches to mobilizing data, this chapter examines the application of information technology, notably to the design and development of computer databases. Like the use of data access agreements, data standards and attention to data quality, judicious use of information technology facilitates the integration and exchange of data, widening the range of applications for which they can be used.

Technological issues have not, for good reason, been reviewed earlier in this document: unless stakeholders have agreed which issues are priority, what information is required to address these issues, and how they are going to organize themselves to respond, it is not easy to determine technology needs. However, when organizational issues have been adequately addressed, the issue of information technology often arises in the form of decisions on which technology to select for automated data management, and how to enable access to on-line information and communication services.

Although data can be managed without modern information technology, the latter provides important advantages over manual techniques[10] in some respects. For instance, computers can be used to structure large datasets consistently, automate validation of data as they are entered, analyse large volumes of data quickly, and produce multiple and varied reports from the same data. Information technology also has certain disadvantages, such as the expenses which are incurred in training, technical support and maintenance. Box 16 highlights several situations calling for the application of information technology.

Box 16: Situations calling for information technology

- Data contain relationships too complex, or are too great in volume for the capabilities of manual filing systems or word processors.
- It is necessary to integrate data from several sources into a combined output.
- There is a need for the data to be shared amongst more than one user in a single organization, or with other organizations.
- Data require extensive searching, sorting or updating.
- Frequent reporting of the data is required.

The best type of information technology to apply to a specific task depends on the scaleability, connectivity, compatibility and sustainability of the technology concerned (see Box 17). Ideally, equipment is tested under realistic local conditions before purchase. So called 'benchmarks' appearing in computer magazines are often optimistic and may not reflect local demands.

Many important characteristics of information technology are also subjective, such as ease of use of an application or device, or the simplicity of a programming language. Selecting technology purely from a list of features is unlikely to be satisfactory. Reliable computer magazines, computer bulletin boards and on-line information services all offer advice on selecting software. Bulletin boards may be accessed via services such as Internet newsgroups and CompuServe forums. They not only store objective assessments of software, but can provide solutions to technical problems via a network of remotely connected users.

Depending on the spatial separation of users, data can be managed using a wide range of different computing architectures, each of which has differing software and hardware needs. Options are available to connect small groups of users within a single building, or much larger groups in disparate locations.

[10]These include manual filing systems such as filing cabinets and card indexes, but also include elementary computer tools such as word processors.

Box 17: Fundamental issues in information technology

- **Scalability**

  As the number of users, data records, or attributes, grow, an application that once performed well on a low-cost architecture can deteriorate in performance quickly. Typically, stand-alone or small network computer architectures are most likely to suffer from this problem—which explains the rise of more sophisticated architectures such as client-server.

- **Connectivity**

  To enable rapid exchange of data between individuals and organizations, electronic connectivity is desirable. This could take the form of a group of locally networked computers sharing a common storage area, or more sophisticated dial-up communication lines to external services such as the Internet and private networks (e.g. CompuServe). The capacity to connect computers together is becoming increasingly recognized as the key to rapid dispersal and exchange of data.

- **Compatibility**

  The issue of compatibility is now diminishing as manufacturers of information technology evolve a range of standard specifications for their products. However, the standards are still too varied and numerous to discount the problem entirely. As far as computing platforms are concerned (i.e. hardware plus operating system), the major decision on compatibility is whether to adapt IBM-PC compatible computers, Macintosh computers, or (usually) larger workstations running the UNIX operating system. At all stages, the best solution is to adopt technology which has been proven to be reliable and useful in circumstances similar to those anticipated, working on the principle that in such cases, compatibility issues are unlikely to cause serious disruption.

- **Sustainability**

  For information technology to deliver long-term improvements in data management effectiveness, sufficient funds and expertise must be available for users to exploit its potential fully, and not be disadvantaged by its costs in terms of training, technical support and maintenance. Technology which has been proven to be effective under the prevailing conditions is usually the wisest choice.

Common computing architectures include single ('stand-alone') computers running local copies of data management applications; locally networked computers with applications running on a fileserver (LAN); client-server[11] architectures; and fully distributed databases consisting of a series of remote computers connected via permanent or dial-up communication lines (WAN).

The most common form of software used to manage biodiversity data is the relational database management system (RDBMS). These systems offer flexibility and performance at modest cost, although they are not designed to manage large-scale textual sources (these are more effectively managed in word-processing packages). Box 18 highlights a variety of specific issues relating to the acquisition of data management software.

DATABASE DEVELOPMENT

Database development involves designing and building the structures necessary to manage one or more related datasets. Generic methods are available to develop databases, and the ideas presented in the following paragraphs attempt to simplify and summarize these.

[11]The third option, client-server, is becoming increasingly popular for medium to large-sized organizations relying heavily on data management for their core business. This architecture is a hybrid of the stand-alone and network options, integrating the best characteristics of personal computers (friendly software and quick response) with the best traits of file servers (high storage capacity, fast data processing, good security).

Box 18: Issues in software selection

- Is the software powerful enough to manage the expected volume of data and number of users?
- What are the long-term plans for the data? Will the scope or the number of users grow?
- Does it contain good facilities for applications development (e.g. data entry screens, querying tools, reporting facilities)? The amount of money spent on applications development usually exceeds the initial costs of the software, so short development periods can result in significant savings.
- Is it a popular product which will continue to be supported and enhanced? It can be beneficial to forsake the latest technology for the stability and support of a well established product.
- Is sufficient experience available for applications development, technical support and maintenance?
- Will it meet user expectations in terms of look and feel?

Database development is partitioned into three phases: the logical design phase, which is independent of the technology used for implementation; the physical design phase, which determines how the logical design will work using the technology selected; and implementation.

Logical database design involves identifying key datasets and studying how these need to be accessed and analysed to achieve the desired objectives. A logical design is independent of both hardware and software, and does not assume any particular method of physical data organization (in practice the technology available—perhaps constrained by budgetary limitations—may affect the final logical design). Focused datasets, such as a collection of data on protected areas, are known as entities; the measurable components of these, such as the area's name, legal status and size, are known as attributes. Box 19 outlines the justification for producing a logical design.

Box 19: Justification for producing a logical design

- It provides a stable base from which to set standards and coordinate the development of the database.
- It provides a conceptual model which is completely free of implementation considerations, and which can be used as a point of reference when adding to or modifying the functionality of the database, or changing the equipment on which it is based.
- It provides a specification which can be used in the evaluation of alternative information technology.
- It provides a base line from which an optimum physical data organization can be produced.

Physical database design involves adapting the logical design to the requirements of the equipment selected for implementation. Transformation of the logical design into the physical design is usually straightforward: entities in the logical model become a tables in the physical model, and attributes become table fields. The way in which relationships between the entities are dealt with depends on which data management software is used. If the chosen software does not support some types of data relationship, then this has to be resolved by altering the logical design.

Each field in the database should be documented in terms of its purpose, data type, size, and order in its corresponding table. When pooled across all the tables of the database, these definitions are known as the data dictionary of the database, and provide a complete description of its structure, format, and use.

DATABASE IMPLEMENTATION

Database implementation involves creating a working version of the physical design in the selected technology. Database tables are populated with the desired data which, ideally, are already computerized and can be imported electronically. Where this is not the case (e.g. the data are available only in hard copy form), they must be entered manually into the database via the keyboard or other input device (e.g. a scanner, or digitizing tablet in the case of maps).

Many data management packages enable users to write routines to regulate data entry, including formating, validation and correction. This concept can be extended to automate other processes, such as querying and reporting data, and transferring data to removable media (e.g. a floppy disk) for exchange with other users. The combination of database tables and special-purpose routines for data entry and other procedures is often referred to as a database 'application'.

Where data are entered via the keyboard, validation checks should begin with rigorous examination of the raw, normally hard-copy, data sources. This can be a labour-intensive and tedious task, but is very important for maintenance of data quality. Where data are not entered directly, but are imported from another electronic source, validation checks should be performed on all the imported data. As an illustration of how errors can be introduced into a database by manual typing, suppose that a data entry screen has 10 fields, and that each field takes on average six characters to fill. If the success rate of the typist is 99 per cent, then the chance of the whole screen being entered correctly is (0.99)(10x6), which, surprisingly, is only 59 per cent.

Automated data validation is especially important in large, possibly critical database applications, into which data are entered regularly by multiple staff. The aim is to enforce a consistent approach to data entry and to draw attention to erroneous data at the earliest detectable point. Validation routines often perform 'reasonableness' checks on data values, such as ranges for numeric fields, or string-length for character fields. It should also be possible to enforce consistency checks such as capitalization and hyphenation. Finally, many packages permit the user to select values from a set of predefined choices. This eliminates the possibility of typographic errors, and can speed up data entry considerably.

In most data management packages, data are retrieved by means of structured requests or 'queries'. Thus, if the user wants to find information on protected areas by providing the search string 'protected area', the search will fail to retrieve records marked 'park', or 'reserve' or 'sanctuary', despite the semantic similarity. The problem of synonyms and equivalent terms is particularly prevalent in the environmental domain due to its multi-disciplinary make-up. This difficulty can be overcome by developing custom search routines using the facilities of the software, and offering them to the user as menu or push-button options. An on-line thesaurus can also assist the user by providing a series of alternative search terms.

DATA SECURITY

A range of operational and data security procedures are necessary to guarantee the integrity of computerized datasets. Data security is equally important in situations where data are not computerized, since it may be considerably more difficult to back-up essential datasets.

In general, threats to electronic data security tend to be greatest where the physical environment is hostile to computing equipment (e.g. extremes of temperature, high humidity or dust), electronic interference is strong (e.g. hospitals, industrial plants, locations near transmitters), power supplies are uneven or unpredictable, or informal (virus-prone) computer networks are the primary means of data exchange.

The most important requirement is to protect data from accidental erasure, which may occur as a result of to human errors in copying and reorganizing files, updating records, and other maintenance procedures; via mechanical failure of disk drives and logical faults caused by power failures and fluctuations; and by the destructive effects of computer viruses.

Box 20 describes a number of operating procedures (protective measures) which combat these threats. The procedures should be elaborated in the form of data security policies and best-practice manuals, enabling all users to review and understand them. Specific emergency plans might be included to recover from situations such as virus attack, hardware malfunction, fire or theft.

The main obstacle to implementing operating procedures is normally a shortage of trained staff. Nevertheless, organizations should accord a high profile to data security: on occasion an entire institution or programme can be forced to close because of the loss of essential data. This once occurred in the South Pacific when a freak wave struck the office of a custodian, eliminating its data. No copy of the data was maintained off-site.

Box 20: Procedures for protecting data

- Regular (e.g. daily, weekly and monthly) backup of all critical data on removable electronic media (e.g. magnetic tape, optical disk).
- Storage of backup media 'off-site'—i.e. away from the workplace in order to restore data after damage or theft of key equipment.
- Periodic 'test' restoration of backed-up data to ensure the procedure is straightforward and effective.
- Periodic 'test' recovery from simulated virus attack, hardware malfunction or other disaster.
- Regular virus checking with up-to-date software.
- Avoidance of unlicensed or 'borrowed' software, computer games, or other personal software.
- Power regulation via the use of uninterruptable power supplies (UPS), surge protectors, and radio interference filters.

CASE STUDIES

8

INTRODUCTION

So far we have explored the production of biodiversity information from the perspectives of custodians managing data, hubs managing coordination, and decision makers managing the development, implementation and review of policies. An informal awareness-raising approach was taken in order to convey concepts to the widest possible readership, rather than a more prescriptive approach for a specific audience. One way of consolidating these concepts is to investigate how different countries have fared in their pursuit of improved biodiversity information in the form of case studies representing a cross-section of conditions.

AUSTRALIA

Environmental information systems in Australia have a history extending back many years. Computerized databases began to be developed from the late 1960s. Some of the key intellectual planning for how to integrate environmental information was done within the Commonwealth Scientific and Industrial Research Organization (CSIRO) from around that period, with some pilot projects conducted in the 1970s. Also around that time, a number of the major museums and herbaria began building databases of animal and plant specimens. The specimen databases were facilitated and financially supported by the Australian Biological Resources Study (ABRS), through the Australian Biogeographic Information System (ABIS). Survey and mapping agencies and nature conservation agencies in the various states of Australia were also beginning to develop spatial and other databases to support their corporate objectives. A large-scale bird atlas project was conducted, by volunteers, over five years in the early 1980s.

Until the late 1980s, these information system developments were largely to support the corporate objectives of individual agencies or for particular projects. Little attention was paid to data interchange or standards, let alone the issues involved in developing integrated systems involving multiple disciplines and agencies, although some pilot efforts were made. A number of environmental controversies in the 1980s focused executive management's attention on the fact that, while trying to resolve complex issues of natural resource management and environmental protection, the key information they needed was not available, when they needed it and in a form they could use.

Large volumes of data were stored in databases throughout the country, but these data were fragmented, incomplete, incompatible, of varying quality and poorly documented. A number of initiatives were then taken. An Intergovernmental Agreement on the Environment was signed between the national and state governments. Under this Agreement, the Australian and New Zealand Land Information Council (ANZLIC) was asked to draft a model data access agreement and to provide advice on data custodianship and related issues. The national and several state governments also set up coordinating committees to oversee and advise on the development of information systems in the numerous departments dealing with environmental issues.

In July 1989 the Government of Australia established the Environmental Resources Information Network (ERIN), with a mission to provide environmental information required for planning and decision-making. Through collaborative arrangements with agencies throughout the continent, ERIN facilitates access to a very large amount of information about the environment—ranging from endangered species to drought and pollution. Through the Environmental On-line Service [http://www.erin.gov.au], much of this information can be accessed from around the world, along with analytical and other tools to help interpret it. Usage of this service continues to grow rapidly: in April 1996 some 600,000 'hits' were recorded, with a growth rate of around 10 per cent per month. The information is drawn from many sources and includes maps, species distributions, documents and satellite imagery. Interactive mapping and modelling systems are available, on-line.

Building such a broad information base has involved close and continuing cooperation and collaboration with research, Government, industry and other stakeholders. The goal is to develop the kind of information infrastructure that can be used to answer questions that are crucial to environmental management and conservation and to ensure environmental sustainability. Information is needed to contribute to the development of environmental policies and programmes, for education, and to assess, manage and monitor biological resources.

Source: John R. Busby, Associate Director for Environmental Science 1991-4, ERIN, Canberra, Australia.

THE BAHAMAS

Following the Rio Summit in 1992, and with assistance from UNEP, the Government of the Bahamas undertook to prepare a biodiversity country study. The preparation process for the country study was a national consultative exercise that allowed contributions from all agencies concerned with biodiversity in the Bahamas. The results from the study were some of the first to be submitted to UNEP.

The country study directly responded to worldwide concerns over the continued destruction of the Earth's ecological systems and the ever increasing number of vanishing species, subspecies and genetic resources. It was realised that the first step toward the conservation of biodiversity in the Bahamas was a comprehensive assessment of its status.

From that international initiative it was agreed that country studies would be completed in other countries to determine what national biodiversity existed and what would be required to assure its continued and/or heightened availability within each country.

A Bahamas National Biodiversity Unit (NBU) was organized to carry out the country study. The unit comprised individuals representing both public and private sector agencies. After submission of the findings, the NBU effectively disbanded, and thus an excellent opportunity was missed to develop an effective national mechanism for monitoring activities in support of the Convention on Biological Diversity, including the 1995 revision of the country study report.

The Bahamas was able to undertake effectively and complete the 1995 review of the report, despite the fact that the NBU was non-operational, because its Government had created the Bahamas Environment, Science and Technology Commission (BEST). The Prime Minister announced its formation at the first meeting of the Conference of Parties to the CBD in Nassau in 1994. The role of BEST was to bring about coordination of environmental matters by quickly becoming the focal point for environmental affairs in the Bahamas.

BEST has established various multi-agency, intersectoral committees in an effort to establish a national network of experts to address specific environmental themes. These initiatives by BEST have begun to realize the objective soughtby the Prime Minister: coordinated action by agencies with an environmental mandate. BEST is thus the national environmental conscience and is charged with implementing the objectives of the CBD and, indeed, other international initiatives supported by the Bahamas.

In 1994 the Bahamas was selected to participate in the UNEP Biodiversity Data Management (BDM) Project, with BEST as the implementing agency. The aim of the project is to develop the necessary infrastructure and coordination to ensure that biodiversity information is made available to decision makers. The BDM project represents an extensive inter-agency consultative process. In the final analysis, success will be judged by the degree to which BEST is able to convince national agencies of the importance of sharing biodiversity-related data in a mutually beneficial process.

The BDM Project began fostering inter-agency cooperation at a national workshop held in Nassau in April 1996. The workshop identified many biodiversity issues as well as their associated information needs. The workshop also identified project-type mechanisms (both short- and long-term) that can be used to address the priority issues. By identifying the agencies that would lead the respective activities, as well as the agencies with whom they needed to collaborate, the workshop began the process of identifying who the custodians of key biodiversity datasets actually are.

It is possible to document a series of biodiversity information management initiatives which the Bahamas has initiated or participated in following the Rio Summit. Hopefully, the BDM Project will form the basis of many further initiatives developed by BEST in its efforts to ensure the sustainable, wise use of natural resources in the Bahamas.

Source: Eric Carey, Project Leader, Biodiversity Data Management Project, Bahamas Environment, Science and Technology Commission, Nassau, Bahamas.

CUBA

In 1995 Cuba embarked on an ambitious process of collecting, formating and analysing its biodiversity data. This work, which directly supports Cuba's implementation of the CBD, was supported by the UNEP under its Biodiversity Country Study Project.

Biodiversity country studies—which are in various stages of completion in more than 30 countries—help rationalize data on a range of biodiversity issues, including which components are important for conservation and sustainable use; which factors need to be monitored; the major threats to biodiversity; and economic valuation of the costs and benefits of conservation and sustainable use of biodiversity. These issues require data on a wide range of biological and non-biological topics, such as threatened species, priority areas for conservation, protected areas, threats to biodiversity, environmental indicators, legislation, institutional capacity and land use. Cuba is fortunate amongst Latin American countries in that it holds the majority of its biodiversity data in-country and, when specimens have been deposited in foreign institutions, copies are usually available in Cuba.

In Cuba, the State is the key stakeholder and decision maker. Other interest groups such as the private sector and NGOs are few in number, although this is now changing. Within this unusual framework there is considerable scope for participatory decision-making with a stronger involvement of civil society than is common in many democracies. Women are also well represented at all levels of decision-making.

The country study was executed by the National Biodiversity Unit (NBU), which was established with funding from a GEF trust fund managed through UNEP. The NBU consists of seven electronically-linked institutions in different parts of the country, coordinated by the National Biodiversity Centre (CeNBio) within the Institute of Ecology and Systematics (IES). Some 28 institutions were directly involved in contributing to the country study, which was divided into five core components. The components, which were coordinated by a contact person within each of the lead institutions, covered social, political and economic issues; biological data; economic costs and benefits; current institutional capacity; and international data sources.

Work commenced with an initial workshop in May 1995, which brought together stakeholders to exchange viewpoints and encourage cooperation. It provided an opportunity to clarify the tasks ahead, stimulate the formation of working groups, and provided the basis of a work plan. The workshop also enabled stakeholders to identify national priorities for biodiversity information on the basis of agreed needs. With the country in transition from a planned to a free-market economy, information on the economic value of biodiversity was set as the top priority. It was felt that, unless the economic value of biodiversity could be demonstrated clearly, it would be hard to argue for conservation in the face of pressures to open up natural resources for exploitation.

Because of difficulties in obtaining modern technology, most biodiversity data were being managed using card index and other manual filing systems, and maps were hand-drawn. Thus there was a need to upgrade data management procedures and transfer large amounts of data into more manageable formats. Despite the lack of high technology, data management practices were excellent and provided first class information for decision makers, albeit by a slow and sometimes laborious process. Data management expertise was mainly built through peer-to-peer communication rather than formal training. This had the advantage that training was very much directed to the immediate tasks at hand rather than being theoretical. As the study was a Government mandate, all institutions were disposed to collaborate and formal data access agreements were not required. Data standards were defined by the major data custodians in conjunction with CeNBio.

Working groups presented their respective components of the Country Study to a second workshop held July 1995 and a third in November 1995. Shortly afterwards Government approval was received and publication took place in early 1996. Facilitating factors included a clear commitment form the coordinating agency (CeNBIo-IES); the fact that the various stakeholders had a solid history of cooperation; the absence of private sector stakeholders and NGOs, which simplified the process; the prevalence of a landscape-level approach to natural resource management which meshes biodiversity interests with other sectors; the availability of large amounts of up-to-date data, not only in the biological sciences but also in land-use, legislation, and demography.

The main obstacles were the short time period of the external support; rapid political and economic change (including market liberaliaation, privatization, decentralization and dollarization) rendering data quickly obsolete; unfavourable economic conditions, limiting the potential for investment in human and technological resources; and political restrictions on support and input from international organizations.

Although brief, the country study process achieved several important goals, including the upgrading of data management systems of NBU institutions, the establishment of nationally important datasets, and training of NBU personnel. The next phase of the process will be to produce the information necessary to draw up national strategies and action plans.

Source: Chris Sharpe, WCMC Consultant, Cuba Country Study Project, 1995.

EAST AFRICA

Although East Africa represents a region (Kenya, the United Republic of Uganda and Tanzania) rather than a single country, its attempts to organize biodiversity data have been conducted in such close cooperation in recent years that it is treated as a single entity in this study.

In 1991 a number of institutions in East Africa began coordinating efforts to manage biodiversity data. This was achieved by means of annual workshops held in different locations throughout the three countries as follows: Bwindi (1991), Nairobi (1992, 1995), Kampala (1993, 1996), and Dar es Salaam (1994). The results of each workshop were published and circulated to all participants and relevant institutions.

The objective of this informal network was to standardize approaches to documenting and researching biodiversity, enabling participants to access data more easily and use this to develop their information programmes more effectively. Separate working groups (technical teams) were established to deal with the development of standard taxonomic lists and habitat classifications; others reviewed data management procedures (including data exchange policy) and regional training needs.

As well as providing an opportunity to review datasets[12] emerging from network collaboration, the annual workshops enable participants to present research progress and exchange experiences in seeking support, applying technology, and accessing international datasets. Improved dialogue and coordination is one of the most important features of the network, enabling relatively ambitious information products to be developed, such as a regional red data list for birds (1996) and, later, other groups.

As the network grew in terms of the number of institutions participating, data holdings and internal capabilities, it became clear in 1993 that tighter coordination was necessary. The annual workshops, however useful, were too far apart to enable agreed targets to be monitored and achieved on time. Indeed, following the meetings, each institution tended to revert to its internal priorities and devote only modest time to regional goals.

None of the participating institutions was able to provide the facilities and staff time necessary for improved network coordination. As a result, it was proposed in 1995 to seek support for a secretariat whose main task would be to enhance communications both within the region and with international organizations such as IUCN, UNEP, WCMC and WRI. Specific tasks of the secretariat were envisaged to be: ensuring continuity of the annual workshops including production of proceedings; production of a quarterly newsletter reporting progress on development of essential datasets; reviews of hardware and software, and summary of international information programmes; maintaining and updating an existing database of institutions and datasets relevant to East African biodiversity; acting as a clearing-house to promote data exchange; and identifying capacity-building and data development needs.

A Steering Committee was elected in 1995 with a mandate to develop these ideas into a costed proposal for submission to a development assistance agency—and subsequently facilitate implementation of its objectives. It consisted of representatives from two institutions in each of the three countries as follows: the National Environment Secretariat (NES) and National Museums of Kenya (NMK) in Kenya; the University of Dar es Salaam (UDS) and the National Environmental Management Council (NEMC) in the United Republic of Tanzania; and the Makerere University Institute of Environment and Natural Resources (MUIENR) and the Uganda Forest Department in Uganda.

The initial proposal was limited in scope since participants agreed that the network should develop slowly and sustainably on the basis of previously existing goodwill and commitment. A range of organizations pledged their support to the secretariat including the East African Natural History Society (EANHS), the East African Regional Office (EARO) of IUCN and WCMC.

Developed from: Concept Paper: Regional Secretariat for Biological Databases, November 1995.

[12]For example, electronic lists of birds and mammals, the List of East African Plants (LEAP), and a regional gazetteer.

EGYPT

Egypt—among other countries—has recognized that biodiversity is an invaluable element of national patrimony. In consequence, scientists and policy makers have become involved in funding and implementing programmes for conserving biological resources. To this end, Egypt signed the legally binding Convention on Biological Diversity in 1992.

Article 6 of the CBD requires ratifying countries to prepare strategies, plans, and programmes for conservation and rational use of their biological resources. A national plan for Egypt comprises elements that may be conceived as a sequence of steps: establish a National Biodiversity Unit (NBU); evaluation of the current status of biodiversity (country study); biodiversity data management; national biodiversity strategy; programme of action (set of projects); implementation; and monitoring progress and follow up. At present, Egypt has completed that first two steps and is actively involved in the third.

The Egyptian Environmental Affairs Agency (EEAA) was established in 1982 and is affiliated to the Council of Ministers. In 1992, the NBU was established under the EEAA (Department of Natural Protectorates), primarily to prepare a national biodiversity strategy. In order to reach that goal, the NBU conducted a biodiversity country study, which gathered and evaluated information on the status and trends of the nation's biodiversity (e.g. habitat diversity and species diversity). It also assessed relevant laws, policies, organizations, programmes, budgets and human capacity. The NBU is currently responsible for implementing the BDM Project, which aims to mobilize biodiversity information for a wide range of users, including planners and policy makers.

Members of the NBU consist of experienced staff from universities, the Agricultural Research Centre, National Institute of Oceanography and Fisheries, Institute of National Planning, National Research Centre, Ministry of Agriculture, Ministry of Interior, Ministry of Tourism, Egyptian Wildlife Service, Zoological Garden, Academy of Scientific Research and Technology, plus a range of NGOs including the Society for the Preservation of National Beauty, Egyptian Society for Preserving Natural Resources, Egyptian Society of Landscaping, Friends of the Tree Society, and Friends of Marine Life Society.

In December 1992, the NBU organized a workshop on biological diversity in Egypt. The main issues discussed in this workshop were the development of the national biodiversity strategy, the economics of biodiversity, and systematic inventories of the major plant and animal groups. A total of 26 invited papers were presented. The participants of the workshop represented the scientific community, conservation agencies and the concerned general public. The workshop expressed the need for a biodiversity data bank in Egypt.

The preparation of the country study was the first element in the biodiversity planning process. In March 1993, the NBU started working on the country study, and this was completed in July 1995. The components of the study were: identification of priority components of biological diversity; collection and evaluation of the data needed for the assessment of these components; identification of the pressures and activities which threaten biological diversity; evaluation of the economic implications (costs and benefits) of the conservation and sustainable use of biological resources; and determination of priority actions for the same. The study resulted in 65 volumes of information, from which both Arabic and English summaries were derived by the NBU.

There is an urgent need to improve the availability of reliable, up-to-date scientific information to support the management and planning of biodiversity in Egypt. The on-going BDM Project addresses this need by helping to mobilize data generated by the country study exercise into an asset for building an enhanced planning capability for sustainable development. The main objective of the BDM Project in Egypt is, therefore, to organize biodiversity data so that it can be used to support biological resource management and planning.

It is hoped that the BDM Project will lead to the establishment of an environmental and natural resources information network in Egypt, which will support national environmental assessment and reporting. The network will help integrate environmental information into development planning, by establishing and encouraging cooperation among national institutions, including government departments.

Source: Dr Esam Ahmed Elbadry, Executive Director of National Biodiversity Unit, Egyptian Environment Affairs Agency, Cairo, Egypt.

INDIA

India is one of the twelve 'megadiversity' countries which, together, possess 60-70 per cent of the world's total biodiversity. Its ten biogeographic zones subsume a very wide range of ecosystems. India has about 7 per cent of the world's flowering plant species, 14 per cent of the world's bird species and, overall, 81,000 species of animal representing 6.4 per cent of the world's identified fauna. Further, one third of its 15,000 flowering plants are endemic to India, plus 14 per cent of its 1,228 bird species, 32 per cent of 446 reptile species, and 62 per cent of its 204 amphibians. The marine habitat covers 7,500 km of coastline extending over 200 nautical miles off-shore into its exclusive economic zone.

Presently, biodiversity data are held unevenly across the country in different, often incompatible, formats. Information based on these data is urgently required by decision makers and other users for different purposes, such as protected areas management, environmental assessment, land use planning and development, awareness-raising and education, research, and prioritisation of conservation activities. A particularly important need is access to reliable data on the socio-economic factors affecting the potential for conservation and sustainable use of biological resources in the regions around protected areas.

Although many institutions collect data useful for biodiversity conservation (some are mandated to distribute this), data are rarely made accessible in reasonable time or in the formats users require, particularly where the data transcend institutional jurisdictions. This is because data are primarily collected for internal use by the institutions concerned, and there is little awareness of the need to build up essential datasets for common, nationally-agreed goals.

The Indira Gandhi Conservation Monitoring Centre (IGCMC) was set up by the World Wide Fund for Nature (WWF-India) in May 1994, with the support of the Ministry of Environment and Forests, Government of India, to provide scientific and management information for biodiversity conservation in India. IGCMC aims to support conservation by serving as a centre of information on the status of India's biological resources, and the pressures they most acutely face, and on the performance of Government and industrial policies on land use, resource management (e.g. water, forests, wildlife) and protected areas. In cooperation with a series of major data management partners, the agreed mission of IGCMC is 'to support biodiversity and natural resources conservation in India through collecting, managing, disseminating and making accessible relevant data and knowledge, and by providing appropriate technical, analytical and networking services'.

Considering IGCMC's priority for producing biodiversity information and its current emphasis on protected areas, its short-term objectives are to gather, interpret and distribute information on threatened plants and animal species, trade in wildlife, wetlands, eco-development planning in and around protected areas, and the distribution and status of habitats and species in the Eastern Himalaya, Western Ghats[13] and Andaman and Nicobar Islands.

The longer-term strategy is to provide more comprehensive information and capacity-building services to a wider range of users, notably in the private sector, by consolidating existing data management partnerships and developing new ones. IGCMC is implementing this strategy with support from the British Overseas Development Administration (ODA).

The sustainable management of biological resources depends on policies which reflect a wide variety of interests. The development of such policies depends upon a similarly wide base of data and information. One task of IGCMC is to increase access to key data via the promotion of common approaches (standards) for data integration and exchange. This demands excellent coordination between IGCMC and its data management partners, which can be facilitated by electronic networking.

IGCMC has developed a model for the integration of diverse and distributed datasets which makes extensive use of Internet-based communication and presentation tools. These enable the growing network of data management partners to cooperate in the development and delivery of information to specific groups of users. No advanced technology will be required by users other than Internet connectivity, which is growing rapidly in India with significant government support.

IGCMC is set to play an important role in providing information to decision makers at many levels in India. One example is the provision of objective information to high-level environmental appraisal committees in the Ministry of Environment and Forests. The role of these committees is to review environmental impact assessments (EIA) for major development projects, and approve or reject the projects as necessary.

[13]Under the 'Biodiversity Hotspots' Conservation Programme of WWF-India

IGCMC will also help the Government of India fulfil its international obligations under the Convention on Biological Diversity. Specifically, it will impact on the following areas: preparation of a national biodiversity conservation strategy (Article 6), identification and monitoring (Article 7), environmental assessment (Article 7), forecasting (Articles 7 and 10), *in-situ* conservation/sustainable development (Articles 8 and 10), *ex-situ* conservation (Article 9), research and training (Article 12), public education and awareness (Article 13), exchange of information (Article 12), technical and scientific cooperation (Article 18), and scientific and technical advisory committee (Article 25).

Source: S. K. Puri, Director, Indira Gandhi Conservation Monitoring Centre,WWF-India, New Delhi, India.

POLAND

Implementation of the UNEP Biodiversity Data Management (BDM) Project began in Poland in 1995. The lead institution was selected to be the Institute of Environment Protection (IEP) on the basis of its accomplishments in the field of biodiversity conservation, and by its existing status as the national focal point for INFOTERRA. In order to ensure a broad-based and multi-participatory approach, the following institutions were also invited to assist in the implementation of the project: the Plant Acclimatization and Breeding Institute, GRID-Warsaw, the Forest Research Institute, the Warsaw Agricultural University, and the Department of Nature Conservation of the Ministry of Environmental Protection, Natural Resources and Forestry, which is responsible for conservation of biodiversity in Poland.

A project team was established in November 1995, consisting of representatives from the above agencies. A coordinating committee was also appointed with representation from the Ministry of Environmental Protection, Ministry of Agriculture, Chief Statistical Office, State Committee for Scientific Research, and key NGOs working in the environmental area.

To date, the main accomplishments of the BDM Project include the testing, refinement and implementation of a national survey of institutions collecting and managing biodiversity data in Poland; the creation of an electronic database to house the survey results; the preparation of electronic presentations on biological diversity in Poland using the multimedia tool, ELADA 21, and also on the Internet via the World Wide Web; translation and refinement of guidelines for managing and networking biodiversity data; and, critically, the preparation of a draft National Biodiversity Data Management Plan.

The purpose of the institutional survey was to assess the current state of capacity for managing data on biological resources, and to identify which hold essential (i.e. nationally important) data. A Polish-language questionnaire, derived from a generic version prepared by WCMC, was issued to almost 800 institutions known to hold relevant data according to directories and additional research. The range of institutions was very wide: botanic gardens and herbaria, ecological foundations, provincial nature conservators, scientific committees of the Polish Academy of Sciences, forest management and research units, university faculties and research institutes, NGOs, national parks managers, agricultural and fisheries agencies, environmental protection inspectorates, regional water management boards, zoological gardens, public organizations and universities dealing with domestic animal breeding.

Each questionnaire was accompanied by a Polish-language copy of the Convention on Biological Diversity, and a letter signed by the Director of the Department of Nature Conservation at the Ministry of Environmental Protection. This pointed to the significance of the questionnaire for improving cooperation and enhancing Poland's capacity to conserve biodiversity. To encourage a good response, the BDM project team followed up the distribution of the questionnaire with interviews and telephone calls. The first round of the survey (April/May 1996) resulted in a 35 per cent response; the second round (June-September 1996) is hoped to boost this figure further.

The National Biodiversity Data Management Plan, which is being drafted by the project team, will reflect local data management needs for biodiversity conservation. The goals of the Plan are to establish an efficient system of collecting, processing, storing and rendering accessible data on national biological resources, and to create mechanisms to enhance decision-making at various levels.

In conformity with the CBD, the Plan will embrace the following activities: identifying national sources of data and information on biological diversity (including responsible institutions); identifying important data types for biodiversity monitoring and resource management; streamlining the creation and operation of databases to manage such data; opening channels and standardizing methods for exchanging data on biodiversity (e.g. data access agreements, data exchange standards); and assessing the information technology needs of those participating in the sharing process.

It is hoped that implementation of the Plan will assist Poland in building policies for environmental protection and sustainable development of its biological resources. The development of laws, regulations, sectoral studies, action plans, economic incentives, and ecological education all depend on the presence of high quality data on biodiversity.

Source: Dr Janusz Radziejowski and Dr Jadigwa Sienkiewicz, Institute of Environmental Protection, Warsaw, Poland.

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GLOSSARY

Agency. A generic term encompassing governmental and non-governmental agencies, departments, units and groups, capable of direct information management responsibilities.

Application. Software fulfilling a specific function on a computer, or an equivalent manual procedure. Can be general-purpose (e.g. a word processor) or custom-built to undertake specific tasks.

Attribute. Properties of an entity which are measured to produce data (e.g. 'name' is an attribute of the 'Protected Areas' entity).

Audience. The target (usually decision-making) individual or group for an information product.

Best practice. Non-legally binding methods of working which are widely perceived as ethical, sustainable and otherwise sound.

Benchmark. A measure of performance against a specific target value or values.

Bulletin board. An area set aside in an electronic communications network where messages can be posted and read by a restricted group of members. Also known as a 'newsgroup'.

CD-ROM (Compact Disc-Read Only Memory). Optical technology which enables large amounts of data to be stored digitally on an optical disk in read-only format.

Client-server. A computing architecture which offers the advantages of both stand-alone and fully networked architectures. Computing tasks are shared efficiently between a high-powered server computer and individual user's workstations.

Common knowledge. The body of knowledge widespread across the globe, which is derived and accepted by the international scientific community.

Computer network. An interconnected group of computers that communicate with each other.

Continuous improvement. A management paradigm promoting the achievement of long-term goals through a succession of small, individually contributing steps, which are frequently reviewed.

Data. Facts derived from measurements or observations about the world.

Data development. The process of building from scratch or upgrading a dataset.

Data dictionary. A repository of information about the definition, structure and use of a database.

Data flow diagram. A diagram showing how information and data flow in an organization or process. Special symbols depict different types of flow.

Data management. The cost-effective storage and maintenance of data.

Data quality. An estimate of a dataset's fitness for use for a specific purpose.

Data standards. Agreed methods of collecting, storing or exchanging data. Standards reduce the transaction costs of sharing data.

Database. A logically structured and consistent set of data that can be accessed and used for analysis (usually managed as computerized files in one or more locations).

Database application. A collection of tools (e.g. data entry screens, reports) which facilitate use of a database.

Database Management System (DBMS). A software application that facilitates storage, maintenance and analysis of data in a systematic way.

Dataset. A collection of data and accompanying documentation which relate to a specific theme.

DBF format. The file format originally used by the dBASE product and now commonly used by other applications for data exchange.

Decision maker. An individual or group responsible for making decisions (which impact on the well-being or management of biological resources).

Decision-making. The process of arriving at decisions, which may be very complex and involve many organizations and individuals.

Digitizing table. A device for inputting map features into a computer.

Electronic mail (e-mail). A network (including Internet) service allowing messages and files to be exchanged between users.

Entity. Item of interest consisting of a series of measurable attributes (e.g. 'Protected Areas').

Entity-Relationship (E-R) diagram. A diagram showing the structure and interrelationships between information and data entities.

Essential dataset. A baseline dataset which is required for the development of multiple information products by one or more stakeholders. Examples include the national boundary, vegetation coverage and human population statistics.

Field. A column in a database table containing data from a consistent data collection or interpretation process.

File. An organized collection of related records.

Fileserver. A specialist computer designed to manage access to shared data storage and management facilities.

File Transfer Protocol (FTP). An Internet service enabling the exchange of files between remote computers.

Flat-file database. A simple type of database containing only one table of data ('flat-file').

Geographic Information System (GIS). A sophisticated combination of software and hardware that enables users to store and analyse spatial data, such as digital maps and remotely-sensed imagery.

Global Positioning System (GPS). A data capture tool allowing mobile receivers to determine their position anywhere on the Earth's surface. Used in aircraft, ships and, increasingly, by field survey teams.

Graphical User Interface (GUI). Software that enables users to interact with a computer by the selection of options and graphical symbols (Microsoft's Windows is a well known example). The contrasting approach is a 'command line' interface.

Hard copy. Data or information that is printed out on paper.

Hardware. The physical components of a computer system such as the computer itself, the screen and peripheral devices such as printers and plotters.

Hypertext. Documents which are structured into electronic 'pages' connected to one another by means of hyperlinks.

HyperText Markup Language (HTML). The language used to format pages on the World Wide Web.

Hyperlink. The connections between pages in a hypertext document.

Information. Data which have been interpreted to facilitate understanding.

Information management. The cost-effective transformation of data into information.

Information product. One or more items of information or an information service designed for a specific audience for a specific purpose.

Information production. The process of developing, packaging and communicating timely information products.

Information system. An organized set of people, processes, data and tools for transforming data into information.

Interface. The tool enabling people to interact with computers.

Internet. A network of interlinked computers around the world which communicate using a set of agreed protocols (communication standards). The Internet provides useful services such as e-mail, World Wide Web (WWW), Gopher and File Transfer Protocol (FTP).

Listserver. An Internet service based on simple e-mail technology, which enables defined groups of users to be reached with a single e-mail message. Primarily used for discussion of a specific topic (similar to bulletin boards).

Local Area Network (LAN). A computer network usually operating within a single site or institution.

Logical database design. The conceptual design of a database which is independent of implementation issues.

Mainframe. A powerful multi-user computer designed to meet the demands of large organizations. Mainframes have been increasingly displaced in recent years by fileservers supporting personal computers and workstations.

Metadata. Literally, data about data (e.g. its location, source, content and quality). Also known as co-data.

Metadatabase. A database designed to manage metadata.

Modem. A device used to link computers over telephone lines. The term is a contraction of modulator-demodulator.

Multimedia. The integration of many types of data in a single application, including text, sound, graphics, and video.

Multi-tasking. A computing environment that enables several programs to be run concurrently.

Network. A group of stakeholders collaborating with each other.

Normalisation. The process of achieving the optimum (least redundant) structure for a relational database.

On-line database. An information retrieval service that can be accessed from computers dialling up over public communication networks.

Operating system. Software controlling access to the resources of a computer, including supervision of other programs. Examples of operating systems are Microsoft Windows and UNIX.

Personal Computer (PC). A computing platform, intended for use by one person at any time. Can be used either as a stand-alone computer or linked into networks. Major types include IBM-PC Compatible and Macintosh.

Physical database. A database which has been implemented in a particular hardware or software configuration.

Policy. A course of action or principle adopted or pursued by an individual, government, party or business.

Process. An activity, function or procedure applied to a resource to create some outcome (e.g. an arithmetic procedure applied to data, or a critical step in a business operation).

Process model. A diagram illustrating the interrelationships between a group of related processes.

Prototyping. An information system development methodology which develops a partial or preliminary version to determine its feasibility and user evaluation. Prototypes are then refined into final applications.

Public domain. Intellectual property available to the public without fee. Many programs developed at universities are released into the public domain.

Query. A request to a database to select and extract data.

Record. A collection of related data about a specific topic, treated as a single unit for purposes of data management or analysis.

Relational database. A database consisting of two or more tables related via common fields.

Relational Database Management System (RDBMS). A computer software application which allows storage of and access to multiple, related files.

Relationship. Describes how two or more entities are related to one another (e.g. 'species' may be related to 'genera' by a 'belongs to' relationship).

Server. A computer or program that provides a service to other programs or users. A network server, for example, enables users to access network resources from linked computers or terminals.

Software. The programs that are run on a computer.

Spatial data. Data which are associated with specific locations on the Earth's surface. Also known as georeferenced data.

Spreadsheet. Software which allows users to manipulate and analyse data in tabular format. Also refers to the data manipulated by the software.

Stakeholder. Individuals or groups having an interest in the well-being or management of biological resources, for example, government agencies, local government administrations, NGOs, community-based groups, the private sector, industry, the general public, politicians, individuals and the international community.

Structured Query Language (SQL). Widespread database querying language used in many relational database packages.

Table. A physical entity in a relational database in which data are laid out in rows (records) and columns (fields).

Theme. A broad data area which may be subdivided into datasets.

Wide Area Information Server (WAIS). A text-based search facility designed for retrieving information from computer networks.

Wide Area Network (WAN). A computer network consisting of geographically dispersed computers communicating via telephone, radio, satellite, etc.

Workstation. High performance desktop computer designed for intensive technical applications.

World Wide Web (WWW). An Internet service enabling users to access information via a graphical, hypertext, interface.

Universal Resource Locator (URL). A unique address describing the location of an information source on the Internet.

xBASE. Data management applications which trace their origins to the dBASE package.